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ANNOUNCEMENT OF THE PUBLISHER.

The ELECTRICAL REVIEW will be sent this week to a number of persons who are not regular subscribers.

We hope that all who receive a copy will decide to give this journal a year's trial subscription. We think that you will be repaid if at all interested.

It is our aim to make this journal thoroughly representative of the entire electrical field. As its name implies, the ELECTRICAL REVIEW is a weekly review of the technical and commercial development of the world of applied electrical science.

The year's issues, fifty-two in number, comprise the annual history of the art.

We invite you to become a subscriber with faith that you will soon become a pleased reader.

ENGINEERING RESEARCH AND THE NATIONAL BUREAU OF STANDARDS.

In a recent issue of one of our technical journals attention is called to the great opportunity which lies before the Carnegie Institute for supplying much-needed data on engineering subjects. The Carnegie Institute is not under government control and the plea is made for the establishment of a great central research laboratory either directly by the government or in connection with the Carnegie Institute.

There already exists in Washington a government department which will necessarily have to carry on much research work along certain engineering lines—it is the National Bureau of Standards.

One is apt to imagine that the Bureau of Standards is a place where the legal standards of weights and measures are kept and where comparisons with them can be made. Now, the Bureau of Standards is not only this but a great deal more. In addition to the standards mentioned, it must establish the legal standards for all scientific measurements. This in itself necessitates a vast amount of patient and long continued laboratory investigation. Further than this, later on the bureau will be called upon to calibrate and certify to the accuracy of such commercial instruments as may be submitted to it. To do this intelligently it will be necessary to make very thorough and detailed studies of all such instruments. The conditions under which they should be tested must be known, the conditions to which they will be subjected in commercial work and the effect which these conditions will have upon the accuracy and permanency of such instruments must be understood. To illustrate: Before commercial alternating-current voltmeters can be accepted for standardization, it will be necessary to have carried out at the laboratory bureau very detailed tests on all types of voltmeters. The effect of temperature or proximity of other instruments or of conductors carrying heavy current must be known. The effect of frequency and wave form upon the indication of the instrument must be investigated. The study of the effect of wave form upon these and other instruments will necessitate far-reaching study in the methods of obtaining and determining various types of waves. It will necessitate a knowledge of wave forms which are found in practice, or such as may be produced by operating conditions in actual use. It will be easily realized that the vast amount of data which must be at hand before the alternating-current voltmeter can be standardized intelligently can only be acquired by long and well-directed research extending throughout the field of alternating-current theory and phenomena.

The illustration might be carried further. The materials which enter into the meter must be understood—springs, iron (if any), copper, alloy, etc.—but enough has been said to indicate that the work of the National Bureau of Standards will be far more than simple comparison of instruments and standards. It will involve research work in the broadest sense, and, fortunately, much, if not all, data collected there will be available to the entire engineering profession.

The Bureau of Standards has, under its able director, made an encouraging start. A laboratory, for which $250,000 has been appropriated, is to be situated on high ground at Chevey Chase, D. C., and will be dignified in appearance. A $60,000 power plant is also to be erected. These, we feel sure, are only the beginnings of an imposing group of buildings which will do credit to the country and from which data of inestimable value will be given to the world. The work which has already been done by the Imperial Physico-Technical Institute, in Charlot-

tenburg, indicates what may be expected from our own bureau. The importance of the work that will be carried on there can not be realized too soon, and it should be brought home to every engineer and scientist in the country, as well as to each member of Congress, so that its work and growth may not be hampered by lack of support, moral or financial.

ELECTROTHERAPEUTIC RESEARCH.

A short time ago a British contemporary published the results of some interesting experiments on the relation between electrical phenomena, particularly that of atmospheric electricity, and certain forms of nervous constitutional ailments peculiar to the human race. This has already become the subject of much comment and discussion in both the lay and scientific press. The author's essential findings seem to focus upon the comparative susceptibility of the inert and the living, but anæsthetized, brain to etheric waves of force. Be the net result of this research of whatever magnitude or slightness of importance, the condition remains that there is much food for thought in this direction.

Of course, no one would advocate the propriety of using the ailing one as a type of condenser, and saturating the living organism with galvanic impulses as a cure-all or elixir. Much good work has already been done by the scientific application of the X-ray to surgery, and in electrotherapeutics and similar pseudo-sciences able students have recorded remarkable advances.

Great as has been the application of electricity to commercial considerations, it has still to accomplish that which will preeminently and positively establish its position as the greatest boon to humanity that the ages of study have produced—the application of electric currents for the diagnosis of mental distress and the alleviation of physical suffering.

Respecting the education of electrical engineers it is, of course, well known that local conditions, such as the instructing staff and laboratory equipment which are presented for the instruction of the student widely vary, but far more important and of deeper moment than all of these is whether the student shall be educated in a broad and liberal manner, or whether he shall be trained in a narrow and restricted school as is an athlete who is trained to some particular contest of strength. The first method results in a man who is equipped for all conditions of engineering life, while the latter would result in producing a man who is adapted for one particular line of thought and action, as is any machine used in the workshop.

From Minneapolis comes the news that one other, eminent in electrical development, Professor Alexander Graham Bell, of Washington, has been honored by the London Society of Fine Arts. Mr. Bell, who was in attendance at the National Educational Convention in Minneapolis, has received word that the decoration known as the Prince Albert medal had been conferred upon him. This award requires the concurrence of the Prince of Wales, and selection is made each year of a person who has distinguished himself in promoting art, manufactures or commerce. Mr. Bell is the fourth American to receive the medal, Captain James B. Eads, Thomas A. Edison and David Edwin Hughes having been selected for the honor heretofore.

It is reported that the severe tests of the Edison storage battery for automobile service on the roads of New Jersey have developed a comparative weakness in the vehicles used. The carriage parts give out before the battery is exhausted or seriously damaged. The manufacturers of these vehicles we hardly believe will be content to rest under this reflection on their constructing skill.

Many of the steam railroads of the country are fully awake to the growing importance of electrical transportation, and have organized electrical engineering staffs to study the question as it affects their interests. It is the wise management that takes up this problem now and keeps in touch with this branch of electrical development that is moving forward with such rapid pace.

EXPENSES OF ELECTRIC LIGHT STATIONS.

On another page of this issue will be found an interesting analysis, by Mr. Alton D. Adams, of the expenses of electric light stations in Massachusetts for the last twelve years. Several points are brought out which are worthy of notice. It is shown that in spite of the increasing efficiency the expenses of the station have increased three times. This increase is of course due to the greater output of the plant, and it is shown that the income has increased faster than the expenses. The items of the analysis are grouped under five heads: Manufacture, distribution, office and management, taxes and miscellaneous. Comparison is made, for each year, of the percentage of the total operating expense of each of the above items. It is shown that while the cost of management has increased, the cost of manufacture has decreased. Thus, comparing 1891 and 1901, it is seen that while the management expense has increased 3.9 per cent of the total, the cost of manufacture has decreased 9.3 per cent. This seems to be a convincing argument in favor of securing and retaining competent officers by offering sufficient inducement. Attention is also called to the fact that while the manufacturing expense has been decreased, there is still much room for improvement. Had old machines been scrapped and replaced by modern units, the showing would have been more striking, a point which is not sufficiently recognized by the smaller companies.

The number of excellent books devoted to electrical science that are constantly published is worthy of note and commendation. The literature of electricity is, in the main, of high grade, and many able writers are now contributors, where there were very few but a short period ago.

The interlacing of the American power-houses, at Niagara Falls, with the Canadian power-house and the transmission of the power at 60,000 volts to Toronto over a three-phase line are valuable demonstrations of the flexibility of the electrical transmission of power.

THE THEORY OF ALTERNATING DYNAMO ELECTRIC MECHANISMS—XLVI.

BY W. ELWELL GOLDSBOROUGH.

ARMATURE INDUCTANCE AND THE CHARACTERISTICS OF THREE-PHASE MACHINES.

In developing the characteristics of a three-phase alternator, a method of procedure similar to that followed in the case of two-phase machines must be used.

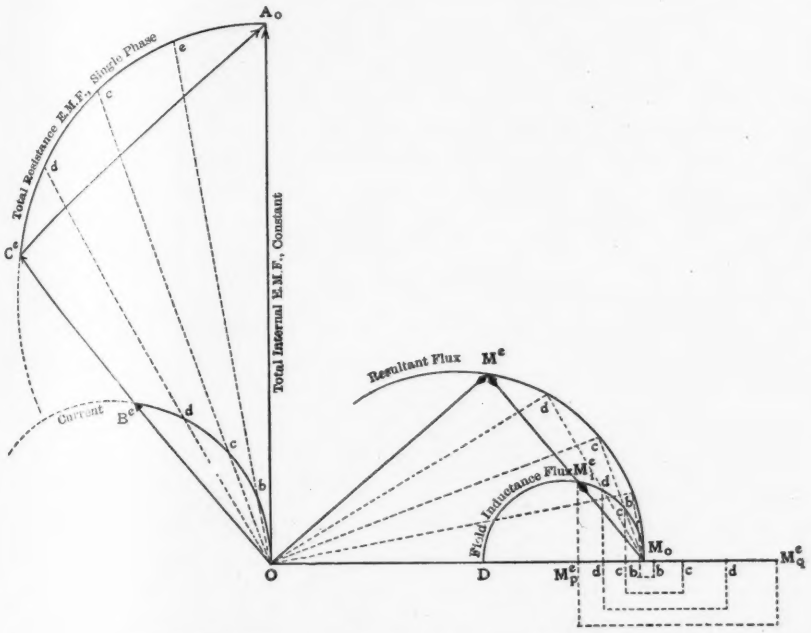

FIG. 168.—ALTERNATING DYNAMO ELECTRIC MECHANISMS.

Here, however, we must remember that the electro-motive force developed in the first phase is effected by the field inductance flux set up by the second and third phases. The extent of this is shown in Fig. 168, where a polar diagram is given like that of Fig. 165. Without modification, this diagram represents the changes which occur when only one of the three phases is non-inductively loaded. In such event, the field inductance flux is represented by the projection of the flux vectors $M_0M^b_i$, $M_0M^c_i$, $M_0M^d_i$ and $M_0M^e_i$ upon OM_0 as the resistance in the external circuit of the machine is successively reduced so as to cause currents having the values OB^b, OB^c, OB^d and OB^e to successively flow through the armature and the line. Corresponding to these currents, the collector voltages are shown by the vectors OC^b, OC^c, OC^d and OC^e. When plotted in rectangular co-ordinates, they give us the regulation characteristic shown in Fig. 170 by the curve *b*, *c*, *d*, *e*, which is labeled "single-phase regulation characteristic." The product of corresponding current and effective electro-motive-force values give the power developed by this phase, and in Fig. 170 these products are plotted relatively to the current values giving the curve *c*, *d*, *e*, that is labeled, "load, single-phase."

Referring now again to Fig. 168, it will be evident that if the first, second and third phases are all loaded equally, and we desire still to maintain the magnitude of the vector values given, it will be necessary to counteract the demagnetizing effect of the second and third phases upon the field magnetism inducing the electro-motive force in the windings of the first phase, as well as the demagnetizing effect of the first and third phases relatively to the second phase, and of the first and second phases relatively to the third phase. This can be done by increasing the exciting power of the field circuit sufficiently to produce at no load a magnetism in the fields equal to the normal no-load magnetism plus twice the projection of the field inductance flux of the first phase upon the vector OM_0. For instance, in order that each of the three phases when symmetrically loaded shall develop an electro-motive force equal to OC^e when each of them is developing a current equal to OB^e, it is necessary to increase the field magnetizing power an amount sufficient to produce on open circuit a field flux equal to $OM_0 + 2(M_0M^e_p)$, where $M_0M^e_p$ is equal to the projection on OM_0 of $M_0M^e_i$. In this case the field flux would be represented by the vector OM^e_q since $M_0M^e_q$, is equal to 2 $(M_0M^e_p)$.

The maintenance of the conditions presented by Fig. 168 in all three of the phases, when they are equally loaded, could only be effected by a constant changing of the field exciting power. If we assume that the alternator is operated under constant field excitation, Fig. 168 must be modified in order to properly represent the conditions which would then exist. These modifications consist in a reduction of each of the flux electro-motive force and current vectors in the ratio of the normal no-load flux plus twice the projection of the field inductance flux to the no-load flux; in other words, in Fig. 168, the flux electro-motive-force vectors, when the three phases are loaded so as to produce a current in each of them equal to OB^e, must be reduced in the ratio of OM_0 to OM^e_q. Such a reduction, uniformly applied for successive loading, gives the phase diagram of Fig. 169. Here it is seen that when the three phases are equally loaded and the currents in them lag 40 degrees behind their total internal electro-motive forces, there is a reduction in the total internal electro-motive force of twenty-five per cent below the no-load values and a corresponding reduction in the current values. The difference between the characteristic developed

TABLE 22.

Data pertaining to Figs. 168, 169 and 170.

	$\frac{2\Phi_p}{10^4}$ Flux.	$\frac{\Phi_q}{10^4}$ Flux.	E Resistance Volts.	I Current Amperes.	E_0'' Total Internal Volts.	E′ Resistance Volts.	I′ Current Amperes.	P_0 Power Kw.	P_0'' Power Kw.
a	0	70.0	1000	0	1000	1000	0	0	0
b	2.0	72.0	985	11.0	972	958	10.7	10.85	10.25
c	7.2	77.2	938	21.5	906	850	19.5	20.20	16.57
d	14.8	84.8	863	30.6	825	712	25.2	26.40	17.92
e	25.0	95.0	762	39.2	747	561	28.9	29 85	16.21
f	35.4	105.4	640	46.4	665	425	30.8	29.70	13.10
g	45.0	115.0	500	52.5	609	304	32.0	26.20	9.72

by the first phase when non-inductively loaded, and by the first phase when symmetrically loaded with reference to the other two, is shown by the difference in the positions of the dotted curve of Fig. 169, and the curve A_0 b'' c'' d'' $C^{e''}$. The demagnetizing or reactive effect of the currents in the three phases upon the field flux is shown by the flux vector distances $M^0M^{b''}_0$, $M_0M^{c''}_0$, $M_0M^{d''}_0$ and $M_0M^{e''}_0$ for the five successive increments of loading.

In rectangular co-ordinates, these effects are shown in Fig. 170. Here the regulation characteristic under three-phase loading shows the drop in the voltage at the terminals of the different phases as the load comes on. Fig. 170 shows as well that the maximum power which can be developed in any one of the phases when the other two are symmetrically loaded is much less than that which can be developed by the same phase when the other two are not loaded. The maximum point reached by the load curve under single-phase working is sixty-nine per cent higher than the maximum point reached by the load curve of any one phase under three-phase working. The mutual reaction of the three phases against the field circuit has the effect then of greatly reducing the load capacity of each phase, as well as causing a marked reduction in the voltage regulation of the machine.

Example 28.

Given: A 45-kilowatt, three-phase generator working at sixty cycles and developing a no-load electro-motive force of 1,000 volts. In this machine, the field inductance of each phase is equal to 43.3 per cent of the total inductance of each phase, and the local inductance of each phase is equal to 56.7 per cent of the total inductance of each phase. The total inductance of any one phase is equal to .044 henry, and the field inductance, the local inductance and the total inductance of each phase may be taken as constant quantities, the values given representing their average values throughout a cycle.

Determine the regulation characteristic when all three phases are symmetrically and non-inductively loaded.

Solution: The solution of this problem requires first the determination of the characteristics developed by one of the phases of the three-phase machine when non-inductively loaded. To do this, we lay off in Fig. 168 the vector OM_0 = 1,400,000 maxwells, or equal to the total number of lines of force entering one pole-face of the machine under normal excitation at no load. At right angles to this, we lay off the vector OA_0 equal to 1,000 volts. On OM_0 and OA_0 as diameters describe semi-circles, and from O lay off radial lines 10, 20, 30 and 40 degrees behind both OM_0 and OA_0, intersecting the semi-circles in the points

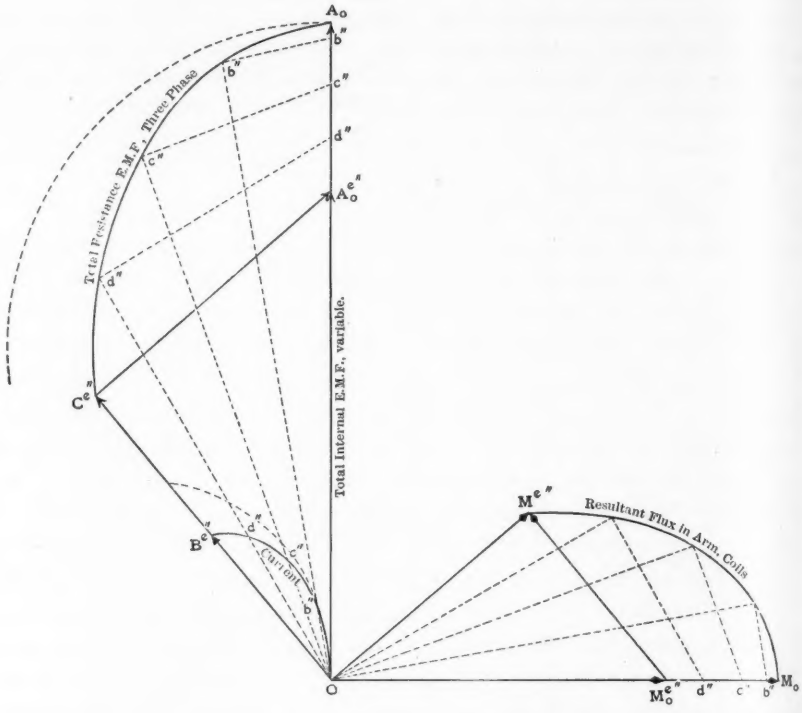

FIG. 169.—ALTERNATING DYNAMO ELECTRIC MECHANISMS.

b, c, d, etc., respectively. By this method of procedure we determine all of the electro-motive and flux values needed

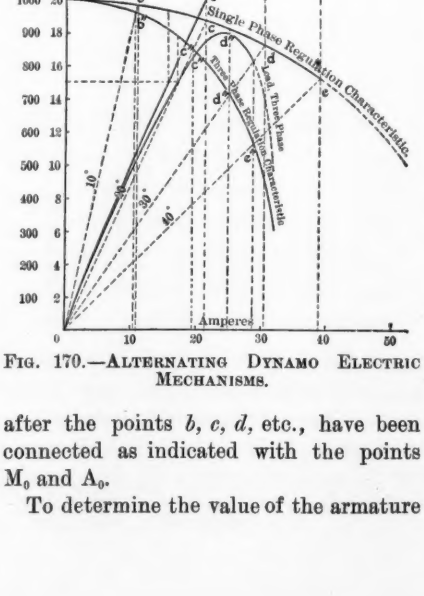

FIG. 170.—ALTERNATING DYNAMO ELECTRIC MECHANISMS.

after the points b, c, d, etc., have been connected as indicated with the points M_0 and A_0.

To determine the value of the armature current which will flow under these conditions, it is only necessary to substitute in equations (54) and (55), since from equation (55),

$$\phi_0 = \tan^{-1} \frac{X_a}{r_a + r_1} \qquad (55)$$

the values of the resistance (r_1) to be placed in the external circuit to produce current lags of 10, 20, 30 or 40 degrees respectively can be determined, and by substitution of these values of r, in equation (54),

$$I = \frac{E_0}{\sqrt{(r_a + r_1)^2 + X^2_a}} \qquad (54)$$

the corresponding values of the currents which will flow in the armature of the machine can be determined. (This method of procedure has already been developed at length on page 212.)

These currents and the collector electro-motive forces (neglecting the ohmic resistance of the armature), which correspond to the current values, are tabulated in the column headed I and E of table 22, and the products of the simultaneous current and electro-motive-force values which give the power output of this phase are tabulated in the column headed P_0. When these data are plotted in rectangular, co-ordinated against the values of the current taken as abscissæ, the single-phase regulation and output curves of Fig. 170 result.

THE PROGRESS OF ELECTRIC SPACE TELEGRAPHY—II.*

(Concluded.)

I have noticed that if electrical oscillations of suitable period be sent from a transmitter, rapid changes necessarily cause induced currents in the windings, which in their turn reproduce on the telephone with great clearness and distinctness the telegraphic signals which may be sent from the transmitting station. Should the magnet be removed or its movement stopped the receiver ceases to be perceptibly affected by the electric waves even when these are generated at very short distances from the radiator.

I have had occasion to notice that the signals audible in the telephone are weakest when the poles of the rotating magnet have just passed the core and are increasing their distance from it while they are strongest when the magnet's poles are approaching the core.

Good results have also been obtained by keeping the magnet fixed and using an endless iron rope or core of thin wires revolving on pulleys (worked by clockwork) which cause the iron to travel through the copper wire windings, in proximity to preferably two horseshoe magnets with their poles close to the windings, care being taken that their poles of the same sign are adjacent.

This detector has been successfully employed for some time in the reception of wireless telegraphic messages between St. Catherine's Point, Isle of Wight, and the North Haven, Poole, over a distance of thirty miles, also between Poldhu in Cornwall and Poole in Dorset over a distance of 12 miles, of which 109 are over sea and forty-three overland.

It would no doubt be possible to obtain signals by causing the iron core to act directly on a telephone diaphragm and in this case the secondary winding could be omitted.

This detector, as I have already stated, appears to be more sensitive and reliable than a coherer, nor does it require any of the adjustments or precautions which are necessarily for the good working of the latter. It possesses a uniform and constant resistance, and as it will work with a much lower electro-motive force the secondaries of the tuning transformers can be made to possess much less inductance, their period of oscillation being regulated by a condenser in circuit with them, which condenser may be much larger (in consequence of the smaller inductance of the circuit) than those used for the same period of oscillation in a coherer circuit, with the result that the receiving circuits can be tuned much more accurately to a particular radiator of fairly persistent electric waves.

As a call a coherer in circuit with a relay working a bell can always be used and if it is found possible to make the magnetic detector record on a registering instrument (as to the possibility of which the results of recent tests have left little doubt in my mind), it may be found possible to receive wireless telegraph messages at a speed of several hundred words a minute.

At present by means of this detector it is possible to read about thirty words per minute.

The considerations which led me to the construction of the above-described detector are the following:

It is a well-known fact that after any change has taken place in the magnetic force acting on a piece of iron some time elapses before the corresponding change in the magnetic state of the iron is complete. If the applied magnetic force be caused to effect a cyclic variation the corresponding induced magnetic variation in the iron will lag behind the changes in the applied force. To this tendency to lag behind Professor Ewing has given the name of magnetic hysteresis.

It has been shown also by Professors Gerosa, Finzi and others, that the effect of alternating currents or high-frequency electrical oscillations acting upon iron is to reduce considerably the effects of magnetic hysteresis causing the metal to respond readily to any influence which may tend to alter its magnetic condition.

The effect of electrical oscillations probably is to bring about a momentary release of the molecules of iron from the constraint in which they are ordinarily held, diminishing their retentiveness and consequently decreasing the lag in the magnetic variation taking place in the iron.

I therefore anticipated that the group of electrical waves emitted by each spark of a Hertzian radiator would, if caused to act upon a piece of iron which is being subjected at the same time to a slowly varying magnetic force, produce sudden variations in its magnetic hysteresis, which would cause others of a sudden or jerky nature in its magnetic condition. In other words the magnetization of the iron instead of slowly following the variations of the magnetic force applied gives a sort of jump each time it is affected by the electric waves emitted by each spark of the radiator.

These jerks in the magnetic condition of the iron would, I thought, cause induced currents in a coil of wire, of strength sufficient to allow the signals transmitted to be detected intelligibly on a telephone, or perhaps even read on a mirror galvanometer. The results obtained go to confirm my belief that this detector can be advantageously substituted for the coherer for the purposes of long-distance space telegraphy.

During the last few years the developments in the practical applications of my system have been exceedingly rapid.

Time does not allow me to give you an account of the many cases in which it has proved its usefulness, but it may be sufficient if I mention that Lloyds have adopted the system exclusively for use at their stations at home and abroad for a period of fourteen years, and that no less than seventeen liners plying across the Atlantic carry permanent installations. In more than one case recorded in the daily papers the system has been of service to vessels in distress, especially in the English Channel.

No less than forty land stations are being equipped with the system in Great Britain and Europe, and over forty vessels in His Majesty's navy are carrying installations.

The adoption of my system in the Royal Navy has brought about a certain slight change of appearance in the rig of the ships. Some naval officers believe that this change improves the ship's appearance; others think the contrary.

The Italian Admiralty after experimenting for some time with the self decohering coherers to which I have referred before, have informed me officially by a letter dated May 24 last, of its decision to equip their war vessels with the same apparatus as has been successfully employed on the transatlantic liners.

On these liners commercial use is made of the system for the convenience of passengers and as an illustration of its commercial workableness I might mention that lately the Campania and Lucania of the Cunard Line have been collecting as much as £60 each trip in receipts derived from passengers' wireless messages.

Nearly two years ago the facility with which communication was possible over distances of nearly 200 miles and the improvements in syntonic methods introduced, together with the ascertained fact, that of the non-interference of the curvature of the earth, led me to decide to recommend the construction of a large power station in Cornwall and another

*An address by William Marconi before the Royal Institution, June 13, 1902.

one at Cape Cod, Mass., in order to test whether by the employment of much greater power it might not be possible to transmit messages across the Atlantic, and establish a transoceanic commercial communication which the monopoly of the Postmaster-General will not apparently permit between the stations if both are situated in Great Britain.

An unfortunate accident to the masts at Cape Cod seemed likely to postpone the experiments for several months, when I came to the conclusion that whilst the necessary repairs there were being carried out, I would use a purely temporary installation in Newfoundland for the purpose of a transatlantic experiment, from which I might at any rate be able to judge how far the arrangements in Cornwall had been conducted on right lines. Before describing the results it may be useful if I give a brief description of the nature of the apparatus used at the transmitting and receiving stations.

The transmitter at Poldhu was similar in principle to the syntonic one I have already described, but the elevated conductor at the transmitting station was much larger and the potential to which it was charged very much in excess of any that had previously been employed, the amount of energy to be used in this transmitting station having been approximately determined bv me prior to its erection.

The transmitting elevated conductor consisted of fifty almost vertical naked copper wires, suspended at the top by a horizontal wire stretched between two poles each forty-eight metres high and placed sixty metres apart. These wires were separated from each other bv a space of about one metre at the top, and, after converging together were all connected to the transmitting instruments at the bottom. The potential to which these conductors were charged during transmission was sufficient to cause sparking between the top of these wires and an earthed conductor across a space of thirty centimeters of air.

The general engineering arrangements of the electric power station, erected at Poldhu for the execution of these plans and for creating the electric waves of the frequency which I desired to use were made by Dr. J. A. Fleming, F. R. S., who also devised many of the details of the appliances for producing and controlling the electric oscillations.

These, together with devices introduced by me and my special system of syntonization of inductive circuits, have provided an electric wave generating plant more powerful than any hitherto constructed.

Mr. R. N. Vyvyan and Mr. W. S. Entwistle have also greatly assisted me in the experiments carried out with the very high tension electrical apparatus employed.

The first experiments were carried out in Newfoundland last December and every assistance and encouragement was given me by the Newfoundland Government.

As it was impossible at that time of the year to set up a permanent installation with poles, I carried out experiments with receivers joined to a vertical wire about 400 feet long, elevated by a kite. This gave a very great deal of trouble, as, in consequence of the variations of the wind, constant variations in the electrical capacity of the wire were caused.

My assistants in Cornwall had received instructions to send a succession of "S's" followed by a short message, at a certain prearranged speed every ten minutes, alternating with five minutes' rest, during certain hours every day.

Owing to the constant variations in the capacity of the aerial wire it was soon found out that an ordinary syntonic receiver was not suitable, although a number of doubtful signals were at one time recorded.

I therefore tried various microphonic self-restoring coherers placed in the secondary circuit of a transformer, the signals being read on a telephone. With several of these coherers, signals were distinctly and accurately received and only at the prearranged times, in many cases a succession of "S's" being heard distinctly, although—probably in consequence of the weakness of the signals and the unreliability of the detector, no actual message could be deciphered.

The coherers which gave the signals were one containing loose carbon filings; another, designed by myself, containing a mixture of carbon dust and cobalt filings, and, thirdly, the "Italian Navy coherer," containing a globule of mercury between two plugs.

For the good results obtained I was very much indebted to two of my assistants, Mr. G. S. Kemp and Mr. P. W. Paget, who gave me very efficient aid during the tests, which the extremely severe weather prevailing in December in Newfoundland made exceedingly difficult to carry out.

The result of these tests was sufficient to convince myself and my assistants that with permanent stations at both sides of the Atlantic and by the employment of a little more power messages could be sent across the ocean with the same facility as across much shorter distances.

The experiments could not be continued or extended in consequence of the action which the cable company, which claims all telegraphic rights in Newfoundland, saw fit to make at the time. Having received a most generous invitation from the government of the Dominion of Canada to continue my operations in the Dominion, it was thought undesirable to continue the experiments in Newfoundland, where I should have probably been brought into litigation with the telegraph company.

I am glad to say that the Canadian Government, on the initiative of Sir Wilfrid Laurier and Mr. Fielding, has shown itself most enterprising in the matter and not only encouraged the erection of a large station in Nova Scotia, but actually granted a subsidy of £16,000 toward the erection of this transatlantic station, the object of which is to communicate with England from the coast of Nova Scotia.

It is anticipated that the Canadian station will be ready for further tests very shortly.

Another station for the same purpose is being erected on the United States coast.

Toward the end of February of this year I thought it desirable to test how far the messages transmitted by the powerful station at Poldhu could be detected on board a ship.

The ship selected was the Philadelphia, of the American Line. The receiving aerial conductor was fixed to the mast, the top of which was about sixty metres above sea level. As the elevated conductor was fixed and not floating about with a kite as in the case of the Newfoundland experiments, very good results were obtained on an ordinary syntonic receiver similar to those I have already described and the signals were all recorded on tape by the ordinary Morse recorder.

Readable messages on tape were received up to a distance of 1,551 miles from Cornwall, and indications were received as far as 2,099 miles. Most of the messages were received in the presence of the captain or the chief officer of the ship who were good enough to sign the tapes. It is curious to observe that signals could not be received at over 900 miles by any of the self-restoring coherers. The reason for this lies probably in the fact that the tuned receiver when connected to a fixed aerial is more efficient. Another result of considerable scientific interest was that at distances

of over 700 miles the signals transmitted during the day failed entirely, while those sent at night remained, as I have stated, quite strong up to 1,551 miles and were even decipherable up to a distance of 2,099 miles. This result may be due to the diselectrification of the very highly charged transmitting elevated conductor operated by the influence of daylight.

I regret that time does not permit me to give you the views which have been expressed with reference to this phenomenon. I do not think, however, that the effect of daylight will be to confine the working of transatlantic wireless telegraphy to the hours of darkness as sufficient sending energy can be used during daytime at the transmitting station to make up for the loss of range of the signals and therefore this business of communicating across the Atlantic will not be one of those works of darkness with which some people connected with cable companies would seem disposed to class it. It is, however, probable that had I known of this effect of light at the time of the Newfoundland experiments, and had tried receiving at night-time, the results would have been much better than those that were obtained.

The day is rapidly approaching when ships will be able to be in touch and communication with the shore across all oceans and the quiet and isolation from the outside world which it is still possible to enjoy on board ship will, I fear, soon be things of the past.

However great may be the importance of wireless telegraphy to ships and shipping, I believe it will be of even greater importance to the world if found workable and applicable over such great distances as those which divide Great Britain from her colonies and from America.

Any of those who have lived in the colonies will easily appreciate what a hardship it is to have to wait perhaps four or five weeks before receiving an answer to a letter sent home. The cable rates are at present prohibitive to a vast majority of people. May it not perhaps be for wireless telegraphy to supply the want?

Undaunted by the non-success of the experiment of lighting the public streets by means of Nernst lamps, the Shipley corporation (London) has ordered a quantity of another new lamp, so far as we, on this side, are concerned, to wit, the Bremer arc. Naturally this is not anything like so much in the nature of an experiment as the Nernst light, but the capabilities of the lamp are a sufficiently unknown quantity as to warrant any data when available being of extreme use to all interested in the lighting question.

EXPENSES OF ELECTRIC STATIONS.

BY ALTON ADAMS.

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In spite of increasing efficiency in the production of energy and rising economy in the application of labor, the expenses of electric stations have been multiplied by three during eleven years. Such is the record for electric lighting systems in Massachusetts. This increase of operating expenses has followed a much greater rise of energy output. For the fiscal year of 1901 the expenses of electric lighting systems throughout the state were 292.5 per cent of the like expenses for 1890. The energy incomes of these stations were 2.94 times as great in the later as in the earlier year. To appreciate how greatly energy outputs have increased beyond expenses, it is only necessary to remember that the period in question was one of falling prices in electrical supply.

In spite of reductions in price, incomes have risen faster than expenses.

EXPENSES OF ELECTRIC LIGHTING SYSTEMS.

Year.	Dollars.	Year.	Dollars.
1890	$1,340,814.60	1896	$2,739,988.16
1891	1,735,206.13	1897	2,888,477.55
1892	2,015,402.86	1898	3,039,340.38
1893	2,397,252.17	1899	3,278,118.30
1894	2,452,982.69	1900	3,545,282.52
1895	2,542,133.61	1901	3,922,408.08

These figures cover all systems of the state except a few small municipal plants. While this expansion of expenses and incomes of electric lighting systems has gone forward, the relative importance of the several items in expense accounts has not remained constant. These items may be grouped under five main headings, namely, manufacture, distribution, office and management, taxes and miscellaneous expenses. Expenses of manufacture include all items of labor and material involved in the operation of electric stations. Distribution expenses cover all labor and materials applied to the care and repair of distribution systems. Expenses of management include all salaries and general office expenses. Taxes represent all expenditure of the companies under that heading. Miscellaneous expenses include all other outlays by the electric lighting systems. To bring out the changes that have been going on the sum of expenses in each year under each of these five headings is divided by the total expense in that year, represented by these five sums. In this way the percentage of the expense under each heading to the total is obtained. Expenses of manufacture remained much the most important item throughout the period, but were subject to material variations, ranging from 58.4 to 49.1 per cent of the total for all items of operation.

PERCENTAGE OF EACH GROUP OF OPERATING EXPENSES TO THE TOTAL.

Year.	% Manufacture.	% Distribution.	% Management.	% Miscellaneous.	% Taxes.
1890	56.1	20.9	8.6	9.1	5.0
1891	58.4	20.5	9.1	7.0	4.7
1892	57.3	19.1	9.6	8.4	5.3
1893	57.8	19.4	10.6	6.7	5.1
1894	56.6	20.0	11.7	6.1	5.4
1895	53.4	21.8	11.6	7.3	5.7
1896	53.1	22.3	12.3	6.0	6.1
1897	52.2	23.1	12.3	5.6	6.2
1898	51.0	24.5	12.6	5.6	6.1
1899	49.9	24.3	12.8	6.3	6.5
1900	49.5	24.8	12.9	5.9	6.6
1901	49.1	24.1	13.0	5.9	7.6

Since 1893 the uninterrupted course of the ratio of expenses of manufacture to the total in each year has been downward from 57.3 to 49.1 per cent. This change has been due, no doubt, to the increasing efficiency of electric stations and the more economical application of labor, and these in turn to the introduction of better steam equipments and larger direct-connected units. While the percentage of expenses for manufacture has been going down, that for distribution has been climbing up from 19.1 in 1892 to 24.8 in 1900. This moderate rise in the ratio of the expenses of distribution to the total is easily explained by the great extensions of distribution systems, especially in the direction of residence lighting, that have taken place in the past decade.

Expenses of management have formed a constantly increasing share of the total during the entire period in question, having stood at 8.6 per cent in 1890 and 13 per cent in 1901. In this connection it may be said that managers and superintendents of lighting systems were but poorly paid during the earlier years of the industry. Miscellaneous expenses include a number of items, such as lawsuits and damages, that naturally fluctuate from year to year; but the general tendency has been downward, the percentage having been 9.1 in 1890, and 5.9 in 1901.

The ratio of taxes to the total expense has risen slowly during the years in question from 5 per cent at the beginning to 7.6 per cent at the end of the period.

Notwithstanding the favorable showing made in the reduction of expenses at electric stations, it is probable that the most important future gains must be looked for at this point of the systems. While efficiency in the consumption of fuel and economy in the use of labor have been carried about as far as the state of the arts permits in some stations, in others low-steam pressures, high temperatures of flue gases, simple engines, wasted exhaust steam, long, heavy shafting and numerous belt-driven units of diversified types are still the rule.

As the largest savings in the expenses of electric systems have been made at the generating stations, and as station charges still constitute one-half of the total of expense items, it is interesting to note the points at which economies have been affected. For this purpose the expenses at electric stations are grouped under nine headings in each year per the following table. As may be seen at a glance, fuel has remained the largest of the nine items throughout the period from 1896 to 1901 inclusive. Moreover, the percentage of the outlay for fuel to the total station expense has shown a decided tendency to rise, having been 44.2 in 1896 and 48.4 in 1901. Fluctuations of the fuel item in the years of 1898 and 1899 were probably due in part at least to the substitution of water power for steam at some stations.

PERCENTAGES OF THE ITEMS OF EXPENSE AT ELECTRIC STATIONS.

Year.	Fuel.	Oil and Waste.	Water.	Wages.	Station Repairs.	Steam Repairs.	Electric Repairs.	Apparatus.	Rent.
1896	44.2	2.4	3.2	33.9	1.8	7.1	4.7	2.3	...
1897	45.9	2.4	3.8	32.5	2.0	7.0	4.4	1.7	..
1898	43.3	2.1	3.2	31.8	3.0	6.5	5.4	1.8	2.3
1899	42.9	2.0	3.4	31.4	2.4	6.8	6.1	1.0	3.5
1900	44.7	2.1	3.2	29.4	2.5	6.4	5.7	1.2	3.2
1901	48.4	2.2	3.0	28.2	2.2	6.7	5.9	0.65	3.2

This rise in the ratio of fuel cost to total expense is due not to lower efficiency of operation, for it can be shown that the efficiency of electric stations was rising during these years, but rather to rapidly increasing electric loads. When such loads are rising rapidly, the fuel expense naturally goes up faster than the total of wages and most other items, because the consumption of fuel must increase directly with the energy output. The percentages for oil and waste are notably constant, varying only a fraction of one per cent during the six years, and the same may be said of the water charges. While the ratio of fuel expenses has gone up that of station wages has fallen steadily from year to year, having stood at 33.9 per cent in 1896 and at 28.2 in 1901. This decline in the relative sums paid for wages has resulted, not only from the fact that the demands of a rising load affect the fuel more quickly than they do the labor item, but also because the changes to large direct-connected units have tendered to materially reduce the requirement for labor in station operation.

Steam-plant repairs have ranged somewhat higher than repairs to electric equipments throughout the period, thus supporting the view that electrical machinery is more hardy and gives less trouble than engines and boilers. Under the heading of apparatus have been placed the items of expense incident to the various small elements of the equipment at an electric station.

The item of rent given for the last four years has been transferred from the heading of miscellaneous to that of manufacturing expenses, because the practice of hiring real estate with water-power privileges as sites for electric generating stations rose to importance in 1896. This practice has greatly increased the item of rents.

Distribution expenses have been arranged under six headings, and the percentage of the sum under each heading to the total of all these expenses has been found. Repairs of lines, lamps, meters and motors have made up the largest expense of distribution in each of the years from 1896 to 1902. Moreover, these repairs have been increased in their percentage of the total expense from 41.5 in 1896 to 46.8 in 1901.

PERCENTAGES OF DISTRIBUTION EXPENSES.

Year.	Wages for Care and Collections.	Repairs of Lines and Lamps.	Cost of Carbons.	Cost of Incandescent Lamps.	Cost of Globes.	Distribution Tools.
1896	33.2	41.5	12.4	11.8	0.9	..
1897	36.7	39.1	11.3	11.9	0.8	..
1898	34.1	42.2	10.3	11.7	0.9	0.6
1899	32.7	43.5	9.3	12.6	1.0	0.7
1900	30.4	45.7	8.3	13.2	1.3	0.9
1901	29.6	46.8	7.1	13.6	1.3	1.4

This increase was to be expected as electric lines grew older and their extent was greatly increased. Wages for the care of lamps and meters and for collectors, on the other hand, have declined from 33.2 to 29.6 per cent of the total expenses of distribution. This decline was probably due in part to the substitution of enclosed for open arc lamps. Another result of this substitution is seen in the fall of the percentage of carbon cost from 12.4 in 1896 to 7.1 in 1901. This latter result followed the reduction in the number of carbons due to their longer life in enclosed arcs. Another but opposite result of the use of enclosed in the place of open arcs has been the increased percentage of the cost of globes, the figures for which were 0.9 in the earliest and 1.3 in the latest year of the period. Incandescent lamps have also increased slightly in importance as an item in the expenses of distribution, due to the growing practice of free renewals. Distribution tools form a small but growing item.

A three-inch manilla rope, 500 feet long, will weigh 1,485 pounds. One wire rope, it is claimed, will outlast three hemp ones.

The Electrical Conductivity of Air.

Recent experiments on the increase in electrical conductivity of air produced by its passage through water, by Prof. J. J. Thomson, are described as follows: The air from a large gasholder, of about 350 litres capacity, was bubbled vigorously through water by making the air in the vessel circulate through a water pump; this treatment increased the conductivity of the air, and when the bubbling had been going on for some time the conductivity of the air was ten or twelve times the initial conductivity. When once the air has been put in this highly conducting state it stays in it for a very considerable time; a large part of the conductivity produced by the bubbling remains in the air forty-eight hours after the bubbling has ceased, nor does it disappear when an intense electric force is kept applied to the gas. The effects produced by the passage of the air through water is similar to that which would be produced if the bubbling produced a radio-active "emanation" similar in properties to those emitted by thorium and radium. The conducting gas can be passed from one vessel to another; it retains its conductivity after passing through a porous plug; passage through a long tube heated to redness destroys the conductivity; it takes, however, a very high temperature to do this; temperatures less than 300 or 400 degrees centigrade seeming to produce comparatively little effect; if the gas is passed very slowly through a long tube filled with beads moistened with sulphuric acid, the conductivity is destroyed; unless, however, the stream of gas is very slow, the air retains a good part of its conductivity in spite of the sulphuric acid. Another point of resemblance between the "emanation" from radio-active substances and a gas in this state is that if a strongly negatively electrified conductor be kept in the gas for some time, the conductor becomes radio-active.

Consul John H. Grout, writing from Valletta, Malta, says: "Of late I have been receiving letters from American houses dealing in various lines of electric goods. This is not a very large field for these articles. The supply of electric energy is under the control of a government bureau, which has a plant providing light for the streets, public buildings and many private houses. The alternating-current voltage in consumers' premises is about 100 volts; the periodicity is about 100 cycles per second. There is no direct current used in the islands. Apart from illumination, there is very little demand for electric goods."

THE CONSTRUCTION OF TELEPHONE EXCHANGES—XXXII.

BY A. E. DOBBS.

REPEATING COILS, TRANSFORMERS AND INDUCTION COILS.

Repeating coils, transformers and induction coils are practically all built on the same principle, except for a difference

FIG. 132.—INDUCTION COIL—CONVENTIONAL WINDING.

in the windings and arrangement of their parts. The difference between a telephone induction coil, for example, and that of a 10,000-watt electric light transformer, is only one of size and windings and arrangement of the iron.

The principle is, that when a current is sent through a coil of wire any other coil in its immediate neighborhood will be likewise affected and transmit an impulse, provided the circuit of the latter coil is also closed, for of course there will be no effect if it is left open. This current in the second coil lasts only for an instant, however, in the case of a continuous current or a single impulse, but by sending a series of impulses through the first coil a like series of impulses will be sent through the second, though in a reverse direction. By connecting these two coils by slipping them on an iron core (Fig. 134) the impulses in the first coil create magnetic impulses in the iron core, which in turn are transmitted into electrical impulses in the second coil.

In order, therefore, to get work out of an induction coil it is necessary that the circuit should be interrupted or reversed quite rapidly. Thus, in an electric light transformer the reversals in the primary circuit may be from 40 to 266 times a second, while in a telephone induction coil these currents reverse according to the voice pitch of the speaker, which may be as low as 200 or as high as 20,000 vibrations a second. As already explained, these impulses passed through one coil will be repeated in any adjacent coils, but the strength of current thus induced depends upon its distance from the first and also somewhat upon the manner of its winding. The two coils might be placed so far apart that no effect is perceptible, or they may be slipped upon a single iron core which greatly increases the effect, or it is possible to still further increase the inductive effect by placing the two upon a closed iron ring as in Figs. 135 or 136, in which the loss of current is trifling. Induction coils also possess another quality, namely, that of "stepping-up" or "stepping-down" the current impressed upon them. Thus a change in the relative windings of the two coils will cause a change in the current delivered; either from a low voltage and large quantity to a high voltage and small quantity, or from a high voltage and small quantity to a low voltage and large quantity, and whether the process is to transpose 20,000 volts to 100 as in a 5,000-horse-power transmission at Niagara or the stepping-up of three volts to several hundred as in a telephone circuit, the process is the same, except that the connections are reversed from low to high tension or *vice versa*. In stepping the current from a low to a high voltage,the low-voltage side is usually wound with a comparatively heavy wire

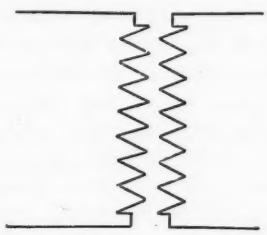


FIG. 133.—REPEATING COIL.

which produces a low resistance, and consequently allows a large quantity of current to flow and impress a strong magnetizing effect upon the core and the other coil.

The high-tension side is wound with a large number of turns of very small wire. The use of small wire is necessary from the fact that the closer the windings can be kept together, and the closer to the iron core, the more efficient the transmission will be. But we also need a large number of turns, and in order to secure closeness of winding a large number of turns and at the same time small wire must be used in the secondary coil, which, incidentally, produces a high resistance.

This high resistance in the secondary winding is not a desirable feature—far from it—but we can not have a large number of turns of small wire without it.

A change in the size and arrangement of the iron core will often make a great difference in the current output.

Two coils placed as closely together as possible, without any iron, will transmit impulses from one to the other, but the effect is greatly increased by the presence of iron in the circuit, which seems to concentrate the lines of force. Should the iron core be too large for the amount of current developed, the action of the coil will be slow on account of the time necessary to saturate the iron. This can be overcome in a measure by winding with heavier wire and increasing the battery, which is generally the case in central battery work where the amount of current sent through the transmitter is large.

Should the core be too small, there is a loss in efficiency of transmission.

The higher the frequency, or rate of vibration, the more difficult it becomes to saturate the core, and for this reason coils made for transmitters using only a single cell of battery are made small and comparatively short. A coil of this kind responds quite readily to the higher tones of the voice, but is lacking in power to carry over long distance. For this reason a Blake transmitter and coil transmit every shade and inflection of the voice remarkably well, but, as more than one cell of battery can not be used nor the coil increased in size, it is weak in long-distance work.

Therefore, as the size of the induction coil could only be increased with the size of the battery, a special form of transmitter that could stand more battery had to be devised.

With the increase in battery power a larger core, heavier winding and a consequent decrease in the resistance of the coils took place, so that the secondary winding of long-distance coils does not often, now, exceed twenty ohms, while the diameter of the core has been enlarged to half an inch or more and its length increased to six inches. It is also necessary that, in order to respond more quickly to the impulses impressed upon it, the core

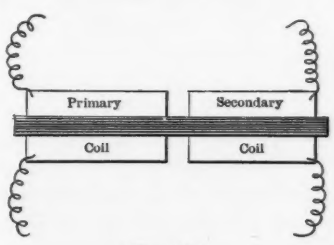


FIG. 134.

should be composed of very fine wires, the smaller the better, and that the iron should be as nearly pure as it is possible to make it. For this reason some manufacturers prefer to use Swedish iron, as it is claimed that the ore obtained in Swedish mines is of a better quality than it is possible to obtain here. This point, however, is disputed by some manufac-

turers of iron wire in this country, who claim that the difference is due solely to the treatment of the iron and claim to equal the best Swedish product in their own mills. But to resume our subject.

In a telephone induction coil we step-up the battery current from a comparatively large quantity and low voltage to a smaller quantity, but a much higher voltage. In order to get quick action in a coil of this kind, the iron core is made comparatively small. When we wish, however, to send a larger current on the line, we increase the size of the core proportionately, and perhaps the size of the wire used in the windings. Thus an ordinary induction coil is usually wound with about 150 turns of No. 22 wire for the primary circuit, while the secondary circuit, usually wound outside, may contain several thousand turns of No. 36 or even No. 40 wire. When it is necessary to transfer the current from one line to another, as, where a grounded line is connected to a metallic circuit, we make the two windings more nearly equal, and greatly increase the size of the iron core, changing its name from an induction to a repeating coil or transformer (it might be explained that the term "transformer," however, is more often used to designate an induction coil that steps a current from a higher to a lower voltage, which is very necessary under some circumstances).

In making electrical drawings, these repeating, induction coils or transformers are represented by saw-tooth lines, as shown in Figs. 132 and 133. In Fig. 132 these saw-teeth are coarse and wide apart on one side, indicating the primary coil and low windings which are placed next to the core. On the other side they are much closer together, which indicates a higher resistance winding. In Fig. 133, the windings being as nearly equal as possible, the size of the teeth on both sides is the same, and therefore indicates a repeating rather than an induction coil. There are many ways in which these coils can be put together. In Fig. 134, for example, two spools may be slipped over an iron core; and a telephone conversation sent through one coil will be repeated into the other. This can also be verified by taking two bell magnets (an ordinary vibrating bell will answer fairly well) and two telephones, first opening the connection between the two spool windings so that the two are separate. By connecting one spool to one telephone, and the other spool to another, though the two telephones are not in electrical connection at all, yet conversation in one telephone will be quite plainly transmitted to the other, provided the two spools are joined together by their armature. This experiment may also be tried with ringer magnets with still better results, but it is necessary that the cores of the two coils should be connected together, affording a magnetic circuit between the windings. Now, we find again that the

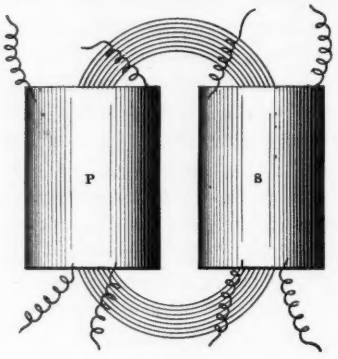


FIG. 135.

efficiency of this coil is greatly increased if the magnet circuit, instead of being open at the ends as in Fig. 134, is a closed ring as in Fig. 135, a form of repeating coil which was very popular for a great many years, but it had one weakness, stray magnetic lines which would, as explained in a previous chapter where there were several on the board, reach from one coil to the other, and produce cross-talk. It therefore became apparent that some form of iron-clad coil was necessary, and the form shown in Fig. 134 was taken up, with the difference that the core wire was made long enough to cover the outside and bent outward so as to form a closed circuit around the coil, similar to that shown in Fig. 136. So far, we have only shown two windings on each coil. Sometimes it is very desira-

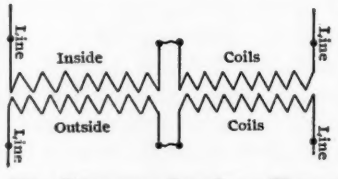


FIG. 137.—REPEATING COIL-SPLIT WINDINGS.

ble, especially in central battery work, that the two windings should absolutely balance each other. When put on separate spools, this is a very difficult matter. We have found, however, that by winding the coil in sections and connecting the different sections together, the balancing becomes comparatively easy.

The original method of securing equal winding was to wind two wires together. If carefully done, as in machine winding, these two wires would have the same length, and consequently the same resistance and number of turns. The objection to this plan, however, was that there was too great a potential difference between the two windings, which extended throughout their entire length, and in case of surgings by heavy currents, there was very apt to be considerable trouble, and the trouble is very difficult to get at, and not at all easy to repair when found. The two-winding plan was therefore abandoned in favor of the sectional single-winding plan.

Fig. 137 shows a diagrammatic representation of a four-coil winding upon a

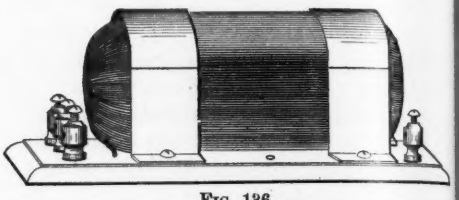


FIG. 136.

single core. It will be noticed that the winding is shown as divided into two parts, spoken of as inside and outside windings, the inside winding being the one nearest to the core of the coil, the outside the one furthest out. Suppose that we were to make 1,000 turns over half the core as one winding, arranged ten layers deep and 100 layers wide, and a similar winding at the other end. We should then have 2,000 turns of wire constituting the inside winding, with the two ends looped out in the middle, and connected as shown. Between each two of these turns there is a winding of thin paper wrapped three or four times around, in order to separate the different turns from each other and prevent possible puncture of the insulation by electrical surgings in the circuit. The two windings next to the core, then, are practically divided up into four other insulated coils by the paper insulation.

Lake Superior figures that copper ore yielding one per cent will pay costs. One and one-half per cent ore will pay a profit. The most economical metallurgical and mining processes are in operation in the Lake region, though but little ahead of some Montana and Arizona copper properties.

Telephones on Tramways—A novel feature of the new municipal electric tramways at Yarmouth, England, is a telephone line, carried upon the street standards, by means of which, in case of accident or breakdown, the driver or conductor can, with a portable telephone carried on the cars, at once get into communication with the tramway headquarters.

A NEW CURVE-TRACING INSTRUMENT.*

BY PROFESSOR R. B. OWENS.

For conveniently and accurately tracing current curves in circuits of small re-

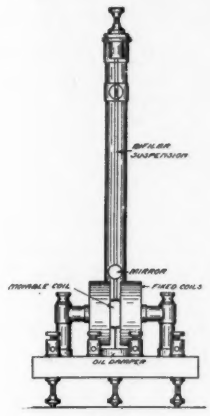
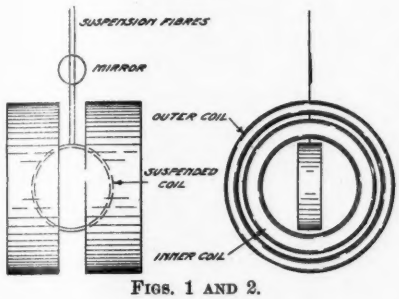


FIG. 1



FIGS. 1 AND 2.

sistance and inductance without appreciably altering their time constants, the instrument illustrated in Fig. 1 was devised some years ago, but having subsequently proved generally useful as a laboratory instrument, a consideration of its characteristics may not be without interest.

In general appearance, it is similar to the ordinary differential galvanometer, with the exception that the usual suspended permanent magnet with attached mirror is replaced by a circular coil of fine wire supported by two thin phosphor-bronze suspensions. The bifilar method of suspension at once allows easy variation of sensibility and affords a means of introducing current into the movable coil. Fig. 2 shows the arrangement of the principal parts in more detail.

The action of the instrument is as follows: The variable current of which a trace is desired is introduced into, say, the outer pair of the two concentric coils, a suitable direct current is sent into the inner pair of coils and a contact maker sends an impulse of current from a constant source of electro-motive force through the movable coil. If the direct current in the inner fixed coil is equal and opposite in magnetic effect to the instantaneous value of the variable current at time of contact, no deflection of the movable coil will be observed. If a deflection, however, does occur, the direct current is varied until such deflection becomes zero, then the direct current, as read by an ordinary Weston ammeter, equals to within a constant the instantaneous value of the variable current for the particular setting of the contact maker used. The constant of the instrument is readily obtained by measuring the ratio of the currents in the two fixed coils required to produce no deflection of the movable coil when a small current from a separate source is sent through it.

Shifting the contact-maker arm, as many points may be obtained as are desired. The instrument is extremely sensitive, allowing perfectly satisfactory traces of currents a fraction of a milliampere effective value to be obtained, and its range can be varied to almost any extent

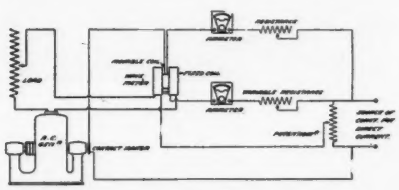


FIG. 3.

by the addition of fixed coils. When measuring very small currents, it must, however, be shielded or corrected for stray fields.

Briefly, the advantages of the instrument are as follows:

(*a*) Its indications are independent of the constancy of contact, being a zero method.

(*b*) All readings are of instruments of the Weston direct-current type, and can be readily converted to absolute values.

(*c*) Wide range and great accuracy.

(*d*) It can be quickly and easily manipulated and has a minimum resistance and inductance.

Some of the applications to which it has been put are:

(*a*) The tracing of alternating current, electro-motive force and current waves.

(*b*) Obtaining curves of growth and decay of current in inductive circuits, when constant electro-motive forces are applied.

(*c*) Obtaining curves of rate of growth and decay of such currents.

(*d*) Obtaining leakage coefficient of large generators, the time constants of whose fields make the use of ballistic or of damped galvanometers for accurate work impracticable.

(*e*) The determination of the variation in a single revolution of the angular velocity of engine flywheels.

(*f*) The determination of the fluctuations in currents from commutating machines.

In Fig. 3 are seen the connections for obtaining an ordinary current wave from an alternating-current generator. A milliammeter is put in series with the movable coil of the instrument as a convenient means of knowing whether or not the contact maker is operating satisfactorily. The average current through this ammeter need not exceed four or five milliamperes; this is so small as not to injure the contact points and allows the period of contact to be extremely small.

For obtaining electro-motive-force waves of an alternating-current generator, a large number of turns of fine wire are used in the outer fixed coils, together with a suitable non-conductive resistance in series with them, the whole being connected across the generator terminals.

In Fig. 4 are given electro-motive-

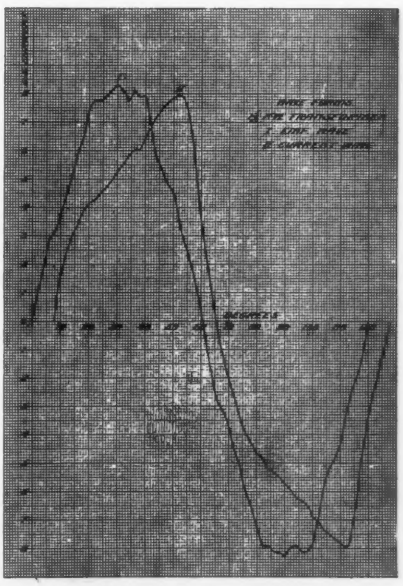


FIG. 4.

force and exciting current waves for a small one and one-half-kilowatt transformer of well-known make. It will be noticed that the smallest variations in both curves are faithfully reproduced. It should also be remarked that such curves check exactly with curves obtained by other reliable methods.

* A paper presented at the nineteenth annual convention of the American Institute of Electrical Engineers, Great Barrington, Mass., June 18 to 21, 1902.

Fig. 5 gives the connections for obtaining the curves of rate of growth of current in an inductive circuit when a constant electro-motive force is applied. A pendulum contact-making device is shown, as it happened to be available, but other means may, of course, be substituted. The inductive circuit as seen, consists of the fields of an Edison bipolar dynamo. About the fields is wrapped a test coil of fine wire. At determined times after the making of the field circuit, the instantaneous values of the current induced in the test coil are measured, and together form a curve of rate of growth of current in main coils. The area of this curve is proportioned to the total induction passing through it. Now, if a second coil, having the same number of turns and of equal resistance, is wound about the armature and the area of the induced current curve in it similarly obtained, the ratio of the first to the second area is the leakage coefficient of the dynamo. Fig. 6 gives the results for a certain field excitation. While not adapted to shop measurements, this method is an absolute one and serves to check the method now commonly used, namely, taking the ratio of the kicks of two similar Weston voltmeters or ammeters, one in a test circuit about the fields and one in a test circuit about the armature.

Fig. 7 shows the curve of growth of current with time in the fields when a constant electro-motive force of 110 volts is applied. The connections of the instrument for this curve are not given, but are very simple, as a little consideration will show.

The variation in a single revolution of the angular velocity of an engine flywheel is measured as follows: A disc dynamo with fields constantly excited is directly driven from the engine shaft and the current trace from it obtained as a function of angular displacement, such current at any instant being proportioned to the angular velocity of the flywheel at the same time. It is necessary to use a disc dynamo or one having a great number of commutator segments, as otherwise the variations in the current due to the angular displacement of adjacent armature coils will mask the variations due to a change in angular velocity.

Most accurate results are obtained by adding to the instrument a third fixed coil, through which is sent a direct current, just sufficient to neutralize the dynamo current corresponding to the minimum angular velocity of shaft or dynamo. The direct current in the second fixed coil will then correspond directly to the variation of angular velocity from its minimum.

In the first experiments made, a dynamo with a twenty-four-part commutator was used, but the curve obtained showed twenty-four variations in one revolution, each of which greatly exceeded in amount the variation of its mean maximum from its mean minimum.

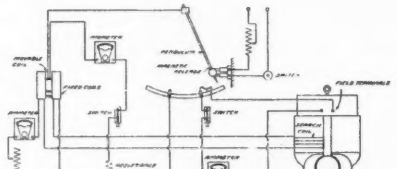


FIG. 5.

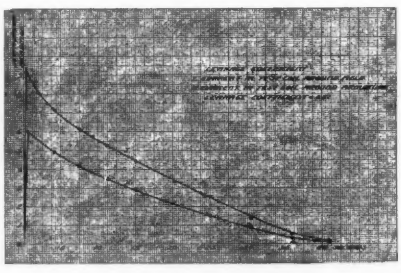


FIG. 6.

Driving the armature of this machine at a uniform speed by means of a motor-taking current from a storage battery, twenty-four similar variations per revolution were observed in the current curve, which measured, of course, the fluctuations corresponding to the pitch of the armature coils in this particular machine.

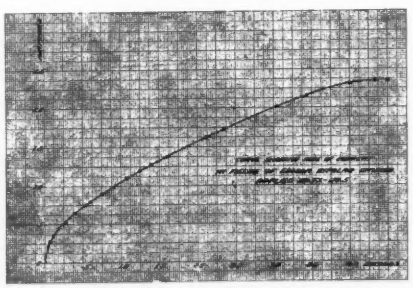


FIG. 7.

Uses for the above instrument other than those cited will readily occur, but perhaps enough has been said to indicate that it has a considerable value for general laboratory purposes.

My thanks are due to Messrs. Smith, Dunfield and Murphy, graduates of the class of 1902, for much assistance in its development and for the taking of observations.

ENERGY LOSS IN COMMERCIAL INSULATING MATERIALS WHEN SUBJECTED TO HIGH-POTENTIAL STRESS.*

BY CHARLES EDWARD SKINNER.

Those who have had occasion to test the dielectric strength of insulating materials by means of alternating electro-motive force are familiar with the fact that heat is always developed in these materials during such test. This is especially noticeable when the test is long continued at a point approximating the breaking down strength of the material. When the amount of material involved is large, ordinary indicating instruments will show at once that there is an actual loss of energy. The fact that energy loss exists under such conditions has been known for more than a decade, being first shown by the experiments of Siemens, and later investigated by others. Published investigations on this subject relate almost entirely to the energy loss in the insulating material, or dielectric of condensers. The law of variation of loss, due to variation of voltage, was first announced by Mr. C. P. Steinmetz† early in 1892. At that time Mr. Steinmetz gave this loss the name "dielectric hysteresis" because of its apparent similarity to the phenomenon known as hysteresis in iron and steel. Since that time other writers, notably Arno,‡ Hess§ and Borel,‖ have made experiments from which they conclude that this energy loss is not in the nature of a dielectric hysteresis, and various theories have been advanced concerning its nature and cause.**

It is not the object of this paper to discuss the theories of the origin or cause, but rather the effects of this loss, and in the absence of a name which can be accepted as descriptive and final it will be spoken of as "energy loss" or "loss."

It is the intention to describe some of the methods employed and to give some of the characteristic results obtained from tests made on various materials used in commercial manufacture, and also on the insulation of finished apparatus. These tests have been made from time to time during the last five or six years, and have covered a great variety of materials. The major part of the tests, however, has been made on materials of a fibrous nature, such as paper and

* A paper presented at the nineteenth annual convention of the American Institute of Electrical Engineers, Great Barrington, Mass., June 18 to 21, 1902.
† *Electrical Engineer* March 16, 1892.
‡ *Electrician* (London), March 3, 1893, and June 23, 1893
§ *Journal de Physique*, April, 1893.
‖ *Comptes Rendus*, May 23, 1898.
** *The Electrician* (London), November 1, 1895.

cloth, both in the treated and untreated state, and the discussion will be largely confined to this class. By treated material is meant a paper or cloth coated with some sort of insulating varnish. The samples used were taken from stock, and standard manufacturing methods were followed as far as possible in preparing them for the tests.

The action of ordinary commercial insulating material under high-potential stress is usually so erratic, owing to surrounding influences, such as temperature, moisture, ventilation, etc., that a considerable number of observations are usually necessary in order to reach any satisfactory conclusions. For this reason the specific tests which are given in this paper are intended to show characteristic and not quantitative results, and are, therefore, not to be taken for other materials or even for other samples of the same material. Individual tests are of little value except as they fit in a series, or unless the conditions surrounding them are known to the minutest detail.

For these tests alternating current at the standard frequencies of 25, 60 and 133 cycles was used, the electro-motive force varying from a few thousand volts to upward of 100,000 volts. The majority of the tests referred to were made on material subjected to a potential stress much in excess of that ordinarily used in actual practice, this being done both on account of the fact that the various phenomena are much more marked at the higher stresses and also because a much smaller amount of material could be used for each individual test. The results, while being true for potential stresses, are of little commercial importance in ordinary low-potential apparatus. They become, however, of the greatest importance in very high-potential working, and especially so with condensers for use on high-potential circuits. The results also have a direct bearing on the question of long continued tests of the dielectric strength of finished apparatus at very high voltages. The various phenomena noted are so interdependent that it is difficult to describe one without referring to others, and at times it will be necessary to anticipate results which are to be described later.

VARIATION OF TEMPERATURE DUE TO VARIATION OF STRESS.

When an alternating high-potential stress is applied to insulating material, the temperature of the whole mass rises, but owing to the fact that all insulating materials are poor conductors of heat, the temperature of the inner portions rises above that of the outer portions, which have a better opportunity of dissipating their heat. A considerable number of tests have been made to determine the rise of temperatures in the interior of a mass of insulating material under different conditions of stress. Usually these tests did not include the measurement of the amount of energy loss, as the results sought were the ventilation required under working conditions and the dielectric strength at various temperatures. The tests were usually made by placing the material between metal plates, which were connected to the terminals of a high-potential transformer. The plates employed for this purpose should always have well-rounded edges to prevent undue stress which occurs at sharp corners.

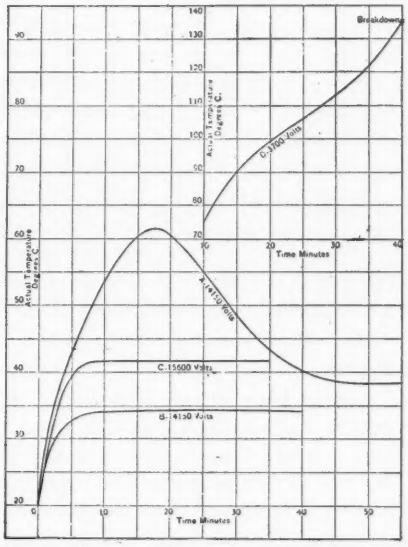


FIG. 1.—SHOWING INCREASE OF TEMPERATURE IN INSULATING MATERIAL DUE TO STRESS.

The size of the plates varied in different tests, but the most satisfactory results were obtained with plates approximately nine inches in diameter, whose edges were rounded to a radius of about one and one-half inches.

Various methods of measuring the temperature were tried, but only one gave entire satisfaction. A mercury thermometer inserted in the material gave trouble, especially at the higher potentials, as the mercury was vaporized by the static discharges in the thermometer tube. A small coil of very fine copper wire was placed in the material and the temperature determined by its increase of resistance. In long-continued tests this method was found unsatisfactory, on account of the rapid oxidation of the copper in the presence of the ozone always generated by such tests. The most satisfactory temperature readings were obtained by placing at the point where the temperature was to be measured, a copper-lead thermojunction connected to a sensitive galvanometer. The outer ends of the couple were kept at 0 degree centigrade by being placed in ice water. By properly insulating the galvanometer, it was found entirely feasible to take readings with a potential stress of 30,000 volts or more across a one-quarter-inch layer of material, with this junction at the centre. In some tests a number of junctions were placed at different points in the material, in order to map out the temperature of the various parts.

In a number of tests the material was arranged as above, and then placed in a box in which was located an electric heater, a fan motor being used to circulate the air over the heater and through the box, so that any desired initial temperature could be secured and with care the surrounding temperature regulated throughout the test. In some instances insulation resistance was measured at intervals, the high-potential wires being temporarily disconnected for this purpose. Usually the insulation resistance was so high as to be very difficult of exact measurement with the apparatus at hand.

The test samples used were built up to a thickness of one-eighth inch to one-quarter inch or more, and tests were made at different voltages up to the ultimate dielectric strength of the material. For most of the tests, current was obtained from a dynamo giving very approximately a sine wave of electro-motive force. The results of this series of tests may be given as follows:

(1) With moderate stress the temperature of the material rises rapidly at first, then more slowly, then becomes constant. The actual rise in the temperature for a given voltage depends on the facility with which the material can dissipate its heat and on the temperature of the surrounding medium.

(2) As the stress is increased a point is finally reached where the heat is developed at a greater rate than it can be carried away, and temperature then rises until the material chars and breakdown results.

(3) When material is not thoroughly dried, the temperature rises much more rapidly than in well-dried stock. The increased temperature can not be accounted for by the increased C^2R loss due to lower insulation resistance. The heat generated tends to dry out the material and the temperature may fall as the drying proceeds.

(4) With a considerable area of material under test, the temperature of small

portions frequently rises above that of the surrounding material to such an extent that on examination these portions are found much discolored, while the surrounding portions remain unchanged. This effect is especially noticeable with treated material not perfectly cured. The final breakdown in such cases is invariably found in one of the heated areas.

(5) The final breakdown in fibrous materials usually results from the burning of the material and not from mechanical rupture. When the electro-motive force applied is far above the dielectric strength of the material, the breakdown may be due to a mechanical rupture. If, however, the electro-motive force is sufficiently low, so that an appreciable time elapses before breakdown occurs, the breakdown is probably due to burning caused by the heat generated in the material. There may be some attendant chemical action, but this is thought to be a result and not a cause of the excessive heat. The lower the electro-motive force applied, the longer the time required to produce breakdown under a given set of conditions.

(6) It follows from (5) that if the temperature is kept low either by providing good ventilation or by artificial cooling, the stress required to cause breakdown in a time test will be much greater than if the material is not so cooled.

(7) The actual temperature measured in most fibrous materials before breakdown occurred was usually 175 degrees centigrade or more. In no case did a breakdown occur directly at the point where temperature measurements were being made, and the temperature at the breaking down point was probably higher than measured, especially as the rise in temperature seems to be very rapid at the point of breakdown just before this occurs.

(8) With a given stress, the initial and surrounding temperature has much to do with the rise. This is due to the fact that the loss in the material increases rapidly with temperature. For example, if the material and surrounding air are at twenty degrees centigrade and the stress applied is 20,000 volts, the rise in temperature will not be nearly so great as if the initial and surrounding temperature is at eighty degrees centigrade. Tests have shown that breakdown frequently results under the latter conditions from a stress that would not injure the material under the former.

Fig. 1 gives some of the characteristic curves of rise in temperature in insulating material when subjected to high-potential stress. Curves A, B and C were taken on a sample of untreated material which was quite porous and capable of absorbing moisture from the air. In this test the material was well ventilated, so that any moisture could be quickly dissipated. The temperatures given are those actually measured, but probably do not represent the highest point reached in the material. Curve A shows the effect of moisture. The temperature rose very rapidly, reaching a maximum, then fell, and at last became stationary. Curve B shows the effect of the same material after very thorough drying. Curve C shows the increased temperature due to a slight increase in the stress.

Curve D, at the upper right-hand corner of the figure, shows the rise in temperature in treated material when poorly ventilated, and the test continued until breakdown resulted. Breakdown in this particular test occurred at a point about four inches from the thermojunction when the measured temperature reached 135 degrees centigrade. It is probable that the temperature measured was considerably lower than that reached at the point of breakdown. The temperature of the surrounding air in this test was kept at eighty degrees centigrade. This curve shows the tendency of the temperature to become constant, but at a point slightly over 100 degrees centigrade the loss becomes so great that the heat can not be dissipated as fast as generated, hence the change in direction of the curve and final breakdown. In numerous tests the material was found to be badly charred on the interior without breakdown having resulted. The curves shown are characteristic and are of the same form as many others that have been taken.

VARIATION OF LOSS DUE TO VARIATION OF TEMPERATURE.

The measurement of the energy loss due to high-potential stress in a reasonably small sample of insulating material, presents a rather unusual problem. The voltage is high, the current small and the power-factor very low. In many of the tests referred to in this paper it was necessary to measure with some degree of accuracy losses of less than 100 watts at an electro-motive force of 2,000 to 40,000 volts, at various frequencies, with a power-factor of less than 0.1. The commercial instruments on the market are totally unsuited for this work.

Many of the measurements to determine the points under discussion were made by means of a calorimeter. This calorimeter consisted of a tank filled with mineral oil, in which the sample was placed. Calibration was effected by passing direct current through a resistance coil immersed in the oil and noting the rise in temperature of the oil, due to various amounts of energy absorbed. The rate of cooling from various temperatures was also carefully taken and was made use of in deducing many of the results. Great care was exercised to secure uniform temperature throughout the body of the oil by mechanical stirring, and the calorimeter was carefully shielded from drafts to prevent variation in the rate of cooling.

The material for these tests was usually built up in the form of a small condenser, with ventilating spaces between the plates so that the temperature could be kept as nearly uniform as possible throughout the mass of the material. In the determinations of the variation of loss due to variation of temperature by the calorimeter method, the whole body of oil and insulation was brought up to some constant temperature, then the high-potential stress applied. The rate of heating or cooling, as the case might be, due to the loss in the insulation being greater or less than required to hold the calorimeter at this constant temperature, was then noted and the actual loss derived by the use of the calibration curves of the calorimeter. These tests required great care, were very tedious, and many corrections were required in deducing the results.

After a considerable amount of work had been done by the calorimeter method, a static wattmeter was constructed and the work continued with this instrument. With this wattmeter, which was admirably suited to this work, a complete curve could be taken in the time required to determine a single point by the calorimeter method. It was a source of considerable satisfaction to find that the calorimeter and wattmeter methods checked each other with a very fair degree of accuracy, especially considering the nature of the materials on which the measurements were made.

In Fig. 2 are given curves which are characteristic in form for the increase in loss due to temperature. These particular curves were taken by the wattmeter method on a sample of material which had been used for some months for other tests and was known to be in the very best condition as regards moisture, etc. This general form of curve has been found to hold for all materials tested, although the rate of change of the loss and the amount

of the loss per unit volume may be very different for different materials and even for the same sample of material under different conditions.

This series of tests has shown:

(9) The energy loss in fibrous material increases with temperature, the rate of increase in the loss being greater than the rate of increase in the temperature.

(10) The rate of increase depends upon the kind of material and on its condition with respect to dryness, etc.

(11) The local heating found in a mass of poorly ventilated material is due to a greater initial loss in one portion, causing increased heating, this in turn causing greater loss, etc., until the temperature finally reaches a point at which charring and breakdown result.

(12) These curves show that the rate of increase of loss is greater at high than at low temperatures, therefore giving the reason for the greater rise in temperature with a given stress when the initial temperature is high than when it is low.

Other tests have shown:

(13) That the loss increases very rapidly, indeed, when temperature approaches the charring temperature of the material.

(14) Losses as great as five watts per cubic inch have been measured in material before serious injury resulted, due to charring. A considerably less loss than this will, however, char the material in time unless special means are taken to dissipate the heat generated.

(15) It follows from considerations of rise of temperature due to increased stress, and increase in loss due to increase in temperature, that a long continued test at high stress may seriously injure the insulation of a piece of apparatus without this being made apparent by the test. This has often been spoken of as "straining the insulation" for want of a better term, the idea being that this was in some way analogous to the straining of a piece of metal beyond its elastic limit. It is probable that this "straining" is always due to charring.

VARIATION OF LOSS DUE TO VARIATION OF VOLTAGE.

As will be seen from the foregoing, there are two conditions to be considered under this head: (*a*) Variation of loss with voltage, the temperature remaining constant; (*b*) Variation of loss with voltage, the temperature varying, due to the loss itself.

(*a*) Variation of Loss with Voltage, the Temperature Remaining Constant—If the loss in a dielectric is due to partial conduction, as has been stated by Hess, it is to be expected that this loss will vary as the square of the voltage applied. This fact was shown experimentally by Mr. Steinmetz in 1892, and the law announced by him at that time as follows:

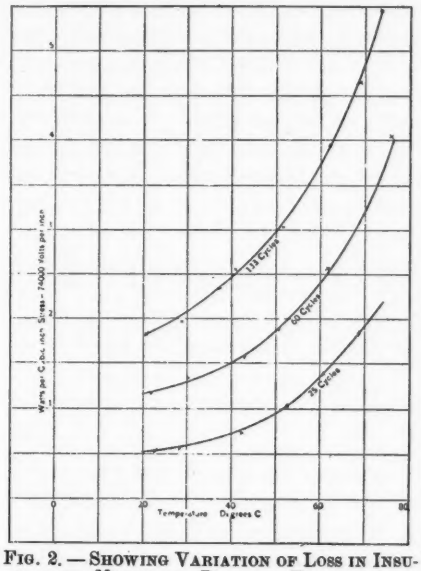


FIG. 2.—SHOWING VARIATION OF LOSS IN INSULATING MATERIAL DUE TO TEMPERATURE AND FREQUENCY.

"The energy consumed by the dielectric medium under alternating electrostatic strain is directly proportional to the square of the intensity of the electrostatic strain."

In his original note on this subject, Mr.

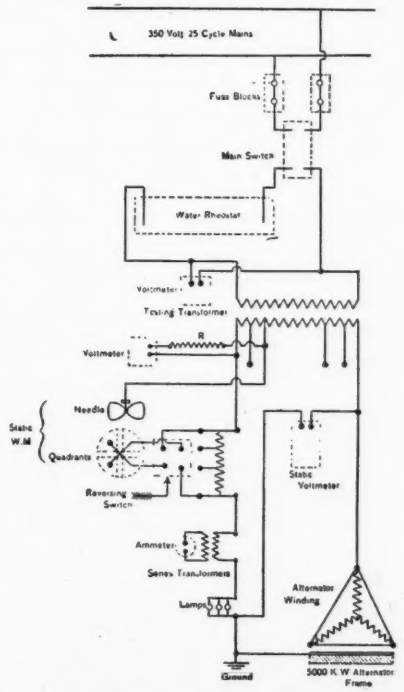


FIG. 3.—DIAGRAM OF CONNECTION FOR MEASUREMENT OF INSULATION LOSSES OF 5,000-KILOWATT ALTERNATOR ARMATURE.

Steinmetz stated that this law was not true beyond a certain limiting strain and was not true at lower strains until the dielectric had been allowed to recover by standing for some hours. This phenomenon noted by Mr. Steinmetz was in all probability the effect of temperature on the dielectric of his condenser. This shows that in tests of this kind care must be taken to prevent the temperature changing during the test and thus masking the results sought.

(16) The tests made show a fair agreement with the law above noted, the increase in loss usually being slightly greater than the square of the electromotive force.

A specific example to illustrate this case is given later in some measurements made on the armature insulation of two of the 5,000-kilowatt alternators built by the Westinghouse Electric and Manufacturing Company for the Manhattan Railway Company.

(*b*) Variation of Loss with Voltage, the Temperature Varying, Due to the Loss Itself—It has already been shown that there is a rapid increase in the energy loss in a body of insulating material due to increase of temperature; also that the energy loss varies approximately as the square of the voltage when the temperature remains constant.

(17) It follows, therefore, that under the usual conditions of high-potential stress the loss will increase more rapidly than the square of the voltage, because the temperature increases at the same time.

(18) The rate of this increase will depend on the facility with which the material can get rid of its heat, and on the length of time the material is subjected to each successive stress in carrying out the test.

(19) It will also depend on the initial temperature of the material and the temperature of the surrounding medium.

It will be seen that many of the conditions named under variations of temperature due to variations of stress apply to this case.

VARIATION OF LOSS DUE TO VARIATION OF FREQUENCY.

Like all the other phenomena described in this paper, it has been found very difficult to make check measurements on the losses of a large number of samples of materials at different frequencies and deduce a mathematical law from the results. In Fig. 2 are shown three curves giving results on a single sample of material tested at 25, 60 and 133 cycles.

(20) It will be noted from these curves that the rate of variation for this particular set of tests is approximately in proportion to the frequency at the lower temperatures, but follows a different law at the higher temperatures.

(21) In some other tests which were

carefully made, the loss varied approximately as the square root of the frequency, but these results are not sufficiently well substantiated to announce as a law.

ENERGY LOSS IN THE INSULATION OF LARGE ALTERNATORS.

Some measurements recently made of the energy loss in the armature insulation of the 5,000-kilowatt alternators built by the Westinghouse Electric and Manufacturing Company for the Manhattan Railway Company should prove interesting in this connection. These tests were made to check some of the results obtained on a smaller scale and to give some of the conditions which exist when very high-potential tests are made on large high-voltage apparatus.

These alternators are wound for a terminal electro-motive force of 11,000 volts, the winding being three-phase star connected. In the design of the insulation, special attention was given to securing great dielectric strength, low dielectric loss and permanency under all conditions of operation. Preliminary tests in the factory had shown a dielectric strength of 80,000 to 90,000 volts for short applications of electro-motive force and a very small rise in temperature for a thirty-minute test at 35,000 volts.

The tests to be described were made on two of these alternators after they had been installed ready for service. The accompanying diagram, Fig. 3, shows the connections of the various apparatus used. The primary current for the testing transformer was obtained from 350-volt (25-cycle) mains, and voltage regulation was by means of a large water rheostat in series with the primary of the testing transformer. The testing transformer had a capacity of 250-kilowatt at 40,000 volts, loops being brought out to give steps of 5,000 volts on the high-tension winding. Three instruments were used to measure the voltage: a direct-reading voltmeter across the primary of the transformer, a voltmeter in series with a high-resistance across a part or the whole of the high-tension winding, and a static voltmeter across the high-tension winding. Current was measured by means of a specially calibrated low-reading ammeter, with a series transformer arranged to multiply the current by four. The small bank of lamps shown was used as a rough check on the ammeter readings.

The losses were measured by means of the static wattmeter referred to earlier in this paper. The quadrants were connected across a variable, previously calibrated resistance and the needle connected to the 10,000-volt loop on the high-tension winding of the testing transformer. The deflection of the needle was read by a telescope and scale. The wattmeter was calibrated by using the voltage across one lamp in a series of four on 500 volts direct current. It may be said for this instrument that after standing over two months in the power-house between tests, the constant had changed less than two-thirds of one per cent.

During the tests one terminal of the testing transformer was connected to the three leads from the armature winding and the other terminal to the frame and to ground. The measuring instruments were connected in the grounded side as far as possible. The temperature of the windings was taken by means of a thermometer near the floor line of the machine. Loss measurements were made at approximately 5,000, 10,000, 15,000, 20,000 and 25,000 volts.

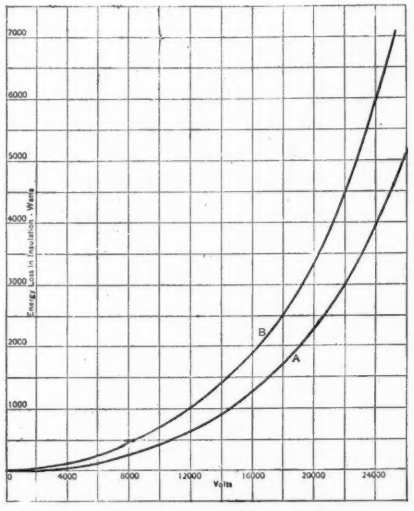


FIG. 4.—SHOWING ENERGY LOSS IN INSULATION OF 5,000-KILOWATT ALTERNATOR ARMATURE.

The accompanying curves, Fig. 4, show the results of these measurements. Curve A was taken on alternator No. 7 and B on No. 6. The temperature of the windings on No. 7 at the time of test was approximately twenty-one degrees centigrade and on No. 6 approximately thirty-one degrees centigrade. These temperatures are only approximate as there must necessarily be some difference in temperature in different parts of a machine of this size, where the parts of the winding are so widely separated from each other. Unfortunately, it was not found feasible to make tests on one machine at different temperatures, and even if this had been done, it would have been difficult to have made accurate measurements of the temperature, for the reasons stated above.

The amount of insulating material under stress in these tests was approximately 19,500 cubic inches, this giving a maximum measured loss of 0.35 watt per cubic inch at 25,000 volts. At a stress of 11,000 volts between the windings and the frame, the loss measured was less than one-kilowatt total for the machine. The loss in the insulation during normal operation of the machine will be much less than this, as the maximum stress to ground when circuits are statically balanced will be approximately 6,400 volts at the lead end of the winding and 0 at the neutral point. As the loss increases approximately as the square of the voltage, the total loss due to normal operation will be only one-third of the loss at a stress of 6,400 volts applied between the windings and the frame. The total loss, therefore, under normal conditions of operation and at the normal temperature at which the machine will run will be less than one-half kilowatt, which is entirely negligible both as regards its effect on the efficiency of the machine and on the rise in temperature. On the other hand, it will be seen that the loss at a stress of 25,000 volts is a very measurable quantity, and the form of the curve shows that this will increase very rapidly as the stress is increased above this point.

From these curves we may see:

(22) The variation in loss due to variation of stress is slightly greater than the square of the stress applied. This increase in rate can not be due to temperature, as the total loss is not sufficient to cause appreciable heating and measurements made during a thirty-minute application of 25,000 volts did not show any variation in the loss.

(23) The increased loss at the higher temperature was somewhat greater than was to be expected from measurements made on small samples of material. This may be due to an actual difference in the loss of the two machines or to the fact that it is nearly impossible to get any accurate measurement of the average temperature of the insulation of a machine of this size.

(24) The loss at 25,000 volts is not sufficient to cause any injurious heating, even in a long continued test.

(25) The rate of increase of loss indicates that at a point not far above 25,000 volts the loss would be sufficient to cause heating and possible damage to the insulation if the stress were applied for any considerable length of time.

It is not possible to state in general terms the safe limiting stress which can be applied in a time test to a piece of

high-potential apparatus, but measurements of the loss and a knowledge of the materials used will give the designer some idea for any particular machine. Such tests are very rarely necessary and should not be required on ordinary commercial apparatus. When a time test is required, it should be at a voltage much below the dielectric strength of the insulation under test.

In conclusion, the author wishes to state that while the work already done has been considerable, there is much more to be done in this line and it is hoped that many of the points now more or less obscure and uncertain may be cleared up in the near future. There are yet many materials to be investigated and experimenters who have the time and patience will find this a fertile field for their labors.

Finally, I wish to acknowledge my indebtedness to my coworkers, Mr. P. H. Thomas and Mr. Miles Walker, for much data and many valuable suggestions in connection with the investigation of this subject. The former particularly in connection with the extensive calorimeter tests carried out by him and the interpretation of their results, and the latter in connection with various temperature and wattmeter measurements. I am also indebted to Mr. H. G. Stott, superintendent of motive power of the Manhattan Railway Company, for the facilities placed at my disposal for making the measurements on the 5,000-kilowatt alternators in the above company's power-house.

The Electric Danger Signals on the Erie Railroad.

An Auto-Electric Installation in the Bergen Tunnel, Jersey City.

THE Erie Railroad Company has placed in operation in the Bergen Tunnel, Jersey City, N. J., a system of electric signals which not only is deserving of merit as rendering almost impossible the danger of an accident in the tunnel, but also for the engineering features which have been displayed in constructing this perfect safeguard against disaster.

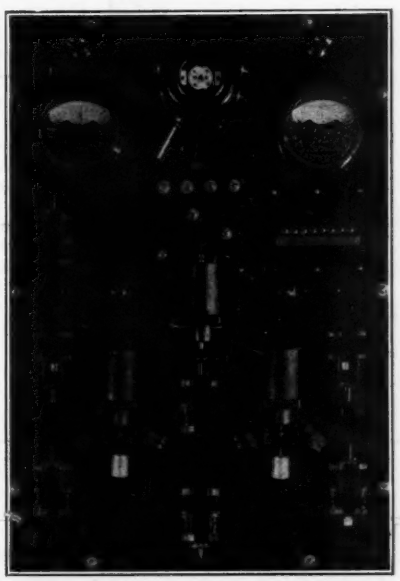
The Bergen Tunnel is 4,400 feet long, and is cut through solid rock. A double track runs through its entire length, and

SIGNAL BOX, LAMP AND WIRING CONNECTIONS, SHOWING METHOD OF SENDING IN WARNING.

in the intense darkness it might be possible for a train to be wrecked after entering the tunnel and part of the wreckage thrown on the opposite track, when a train entering the tunnel from the other direction could not be warned of this condition of affairs, and would thereby be subjected to the chances of a serious accident were there not some system for notifying the engineer that danger was ahead. At distances of 200 feet apart, signal boxes about six inches square have been attached to the walls of the tunnel on both sides. In each of these boxes a plug is adjusted, the metal end of which is flanged so that it makes contact with two brass clamps which close tightly upon the ferruled end. This maintains a closed circuit on the signal line, and in the front of the box there is a micanite knob about two inches in diameter at the end of the metal contact plug. These plugs are sealed in with wax so that the moisture and soot which are prevalent in the tunnel may not affect the working of the circuits, but are secured in such a manner that only a slight effort is necessary to remove them.

At distances of fifty feet apart electric lights are attached to the walls of the tunnel on both sides, there being a lamp above each signal box. These lamps are eight and one-half feet above the rail, or about on a level with the bottom of the window on the cab of a locomotive. In case of an accident, involving the blocking of one or both of the tracks, it is the duty of any one of the trainmen who may be nearest to one of the boxes to pull out the plug opening the circuit, allowing the knob to hang at the side. He subsequently reports to the tower-man so that the box may be located and properly sealed. As soon as the circuit is opened, the signals on both sides of the tunnel are automatically lighted, and the engineer of any moving train must immediately stop upon receiving such a signal. The signals are distinguished at a distance of 110 feet under the worst conditions, and the signal boxes are located by white enameled plates, about ten inches square, placed immediately underneath.

Two special houses have been constructed, one at each end of the tunnel, for containing the storage batteries which operate the lighting system of the tunnel. In each of these, 100 cells of Willard storage battery of 100 ampere-hours capacity are stored, the charging current on the east end being taken from the



SWITCHBOARD IN SIGNAL-TOWER, SHOWING SOLENOIDS, METERS AND ARC LIGHT CUT-OUT.

1,500-volt Brush arc circuit at 9.6 amperes, used for lighting the yards at the terminal in Jersey City, and the batteries are charged once a week for about four

hours. In order that the batteries may have some work to do to keep them in prime condition, two incandescent lights are used to light the signal-towers at each end of the tunnel. The current for charging the batteries at the west end of the tunnel is taken from the city circuit at 500 volts, and is cut down to ten amperes to suit the batteries. Switchboards containing the apparatus for operating the circuits are located in each of the signal-towers, and the charging current is regulated from each of these.

The storage battery houses are strongly constructed, and raised about three feet above the ground level on substantial concrete piers. Special arrangements have been made to guard against the batteries being affected by the vibrations of passing trains, and each cell is mounted upon an individual tray resting on insulating porcelain studs. The battery racks are further insulated by several coatings of insulating paint, and proper ventilation is provided by perforations under the eaves of the roof which covers an attic air chamber.

ing the electric light leads, and great care had to be taken in devising that which would properly suit the requirements which the service would indicate. At all times there is a great amount of moisture present, and the carbon which forms on the walls, and anything abutting

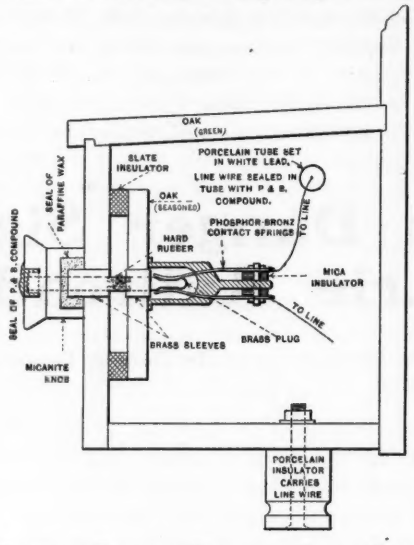


Diagram Showing Detail of Signal Box.

leads run half through the tunnel on each side. These are carried on oak plugs, ten feet apart. The electric light leads are carried on the top, and the signal wires underneath. One signal wire runs clear through the tunnel, and the other is cut in at every box, the through wire being the return of the metallic circuit. The electric light circuits are made in four divisions, so that if any part of a wrecked train should be thrown against the current-carrying wires it would automatically open the signaling circuit and leave at least three whole sections of the lights in operation, and all of the lights up to the point of rupture on the side which might be struck. The electric light leads are composed of No. 4, stranded, four sixty-fourths, Okonite rubber wall cable. This is lead-covered and braided to furnish proper insulation and to protect it from ordinary injury. The signal wire is No. 12 copper, rubber-insulated wire, lead-covered. There are altogether 184 ruby glass, 200-volt eight-candle-power lamps, 92 on each side of the tunnel.

The greatest precaution has been taken

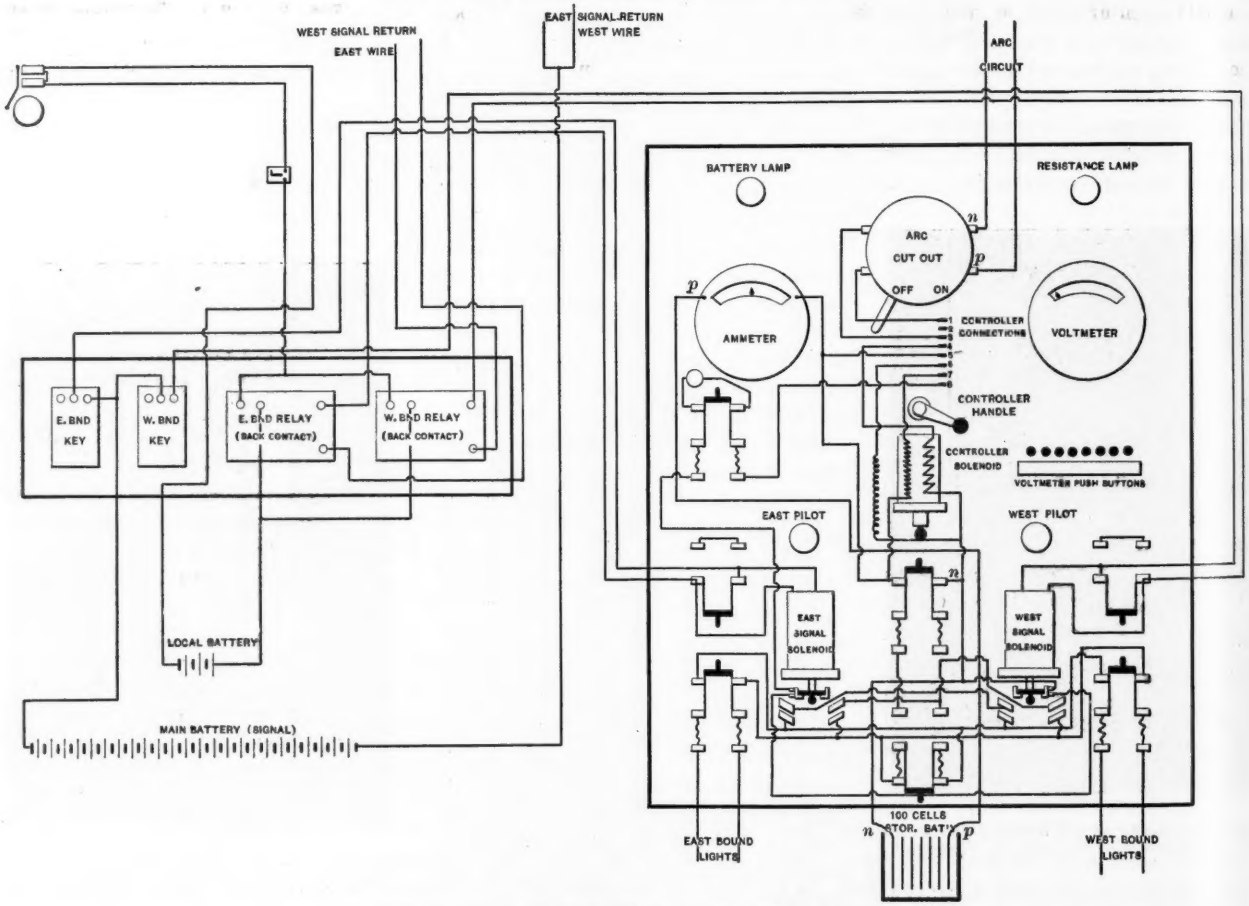


Diagram Showing Detail of Wiring and Switchboard.

The physical conditions which exist in a tunnel of this nature presents a serious difficulty in the way of properly insulat-

in the tunnel, is about as good a conductor as could be obtained for facilitating the leak of a stray current. The electric light

to make every point on the line proof against accidental leaks. Lead leads are connected from the mains to weather-proof

lamp sockets, and at each division made in the circuit for the lamp connections special junction boxes have been constructed, the connections being carefully soldered, taped, and the boxes filled with P & B insulating compound. The lighting circuits are afforded a further protection against damage from lightning flashes, being paralleled from the towers to the portals of the tunnel by a barbed wire grounded at every 100 feet.

The operation of the circuits is essentially as follows: Signal wires are run on each side through the complete length of the tunnel. On each side one wire makes a complete span, the other being cut in at each signal box. This is connected in series with gravity batteries of thirty cells which are located in the signal-towers. At each switchboard a solenoid is connected in series with each of these signal lines, a plunger being held directly above the two arms of the light circuit. This signal line is also connected in series with a relay which operates a local circuit to ring a warning gong in the signal-tower; this being cut out by a manual switch by the tower-man after the signal has been received. Should occasion require the pulling of the plug in any of the signal boxes located in the tunnel, the instant that the plug is removed the circuit is left open, when the magnetism in the corresponding solenoid on each switchboard ceases and the plunger drops, completing a circuit between the storage batteries and the light current leads in the tunnel. The lamps immediately flash a red light and continue burning until they are switched off by the operator at the signal-tower. The switchboard arrangements are complete in every detail, and a thorough working test is made of the service condition of every part of the system each day. Small switches are arranged so that each lead may be tested individually, and a series of eight button contacts is so located that the charge on the battery, both sides of the lighting circuits and the signal lines, is registered, and in the same manner a leak on any line is readily detected.

Should a signal be received while the batteries are being charged, to avoid the possibility of the 1,500-volt current being thrown on the circuit, a controller solenoid situated in the centre of the switchboard at each of the signal-towers automatically throws off the charging current, so that no matter what may be the condition of charging at either end station, the charging current is cut out and the current from the batteries automatically thrown in on the light circuit.

The installation was made by E. V. Baillard, of New York city, under the personal direction of Mr. Fred L. Blendinger, superintendent of telegraph service on the Erie. Mr. Blendinger has solved in an eminently satisfactory manner an intricate problem. Everything that the most advanced engineering skill could suggest has been done to reach perfection in detail. The tunnel is operated as a signal block, and the possibility of accident is rare, but the satisfaction that the Erie company can take in thus safeguarding its service will compensate for the expenditure involved.

The American Association for the Advancement of Science.

The meeting of the American Association for the Advancement of Science, and affiliated societies, held at Pittsburg from June 27 to July 3, was one of the most successful which the association has ever held. Four hundred and thirty-five members of the American Association for the Advancement of Science were in attendance, and in addition to this there were about 200 members of affiliated societies present. A number of important measures concerning the future of the association were considered, and several amendments to the constitution were adopted. In order, in future, to give proper publicity to the work of the association, a press secretary will be appointed by each section and affiliated society whose duty it will be to see that the proceedings are correctly and interestingly reported from day to day. About sixteen new members were elected during the Pittsburg meeting, and eighty members were made fellows.

Mr. George Westinghouse was elected to an honorary fellowship in the association, this honor being bestowed upon him out of respect to the inventive powers and executive ability which have in the past decade added materially to the great and substantial progress made in the field of applied science.

A number of interesting social events were observed, and four interesting public lectures were given to the citizens of Pittsburg by the association and affiliated societies. The papers which were read before the association proper and during its session, and of the affiliated societies, were of a high order. About 360 papers were presented, and of these, those presented by sections B and D in physics and mechanical engineering, respectively, were of an especially interesting nature. Of forty-five papers read, either actually or by title, before section B, seventeen related to electrical subjects. An unusually large number of papers were read before the mechanical, science and engineering section, many of them of high practical and scientific value.

President Ira Remsen, of the Johns Hopkins University, was elected president of the association, and will succeed President Asaph Hall at the next meeting, which will be held in Washington, D. C., December 28, 1902, to January 3, 1903.

The Society for the Promotion of Engineering Education was in session June 27 and 28. A number of papers of great interest and profit were read and discussed. At the election of officers for the ensuing year, Calvin M. Woodward, dean of the School of Engineering, Washington University, St. Louis, was made president; John T. Flather, University of Minnesota, and Frederick W. McNair, of the Michigan College of Mines, vice-presidents; Florence A. Waldo, Purdue University, secretary; Arthur N. Talbot, University of Illinois, treasurer.

Wireless Signals Not through the Earth.

To the Editor of the Electrical Review:

It was with enthusiasm and delight that I read in the Electrical Review of May 24 and 31, Mr. Rankin Kennedy's theory of the wireless transmission of signals. From the very first published successful experiments of Signor Marconi, I have given this as the most plausible theory and have in preparation an article similar to that published by Mr. Kennedy.

It is to be hoped that at an early date your editorial suggestions will be carried out, and possibly throw some light on this very valuable and interesting subject. That the impulses received on the receiving instrument are purely electrical, a little analysis will clearly show, and how these impulses are transmitted through hills and good earths to an earth-plate with an inferior grounding capacity, does not seem within the bounds of reason. Then considering this with the small amount of energy in the transmitting device, we must look to a disturbance of a charge upon the earth for these manifestations.

As metallic spheres do not hold their charge within, but in suspension, and any disturbing influence at any point will manifest itself all around the electrical zone, then it is not at all improbable that the earth is unlike the metallic sphere. Evidently something more should also be known about what occurs at the transmitting spark-gap—that is, the nature of the impulse given out by a disruptive discharge.

J. E. Peavey.

Cincinnati, Ohio, July 2.

Reviews of Current Engineering and Scientific Literature.

Giving Concisely the Substance of Important Papers in the Scientific, Electrical and Engineering Press of the World.

Asynchronous Generators for One or More Phases.

This is another contribution by Heyland on this method of compounding alternators. As is known, the compounding consists in placing around the field a squirrel-cage winding. Currents from the armature are led into this at various points, and the compounding is effected by these currents. The theory is explained graphically, and methods of winding illustrated by diagrams. The results of the compounding are shown by curves from actual tests, the whole being a valuable addition to this important subject. — *Electrotechnische Zeitschrift* (Berlin), June 26.

Carpentier's Torsion Perméameter.

This instrument is designed to measure magnetic quantities by the zero method. It consists of an iron ring of rectangular cross-section divided into two parts, and pierced at one end of each section by a rectangular opening. Into one of these openings is inserted a tube containing a small magnetometer, supported from a torsion head. The specimen to be tested is inserted in the exciting coil and then placed within the ring across one diameter. The exciting force is measured by an ammeter graduated to read it directly. The torsion head measures B. As there is a small correction to be made for the force required to drive the flux through the iron ring, and as this is proportional to B, this correction is indicated on the torsion head. The instrument is well mounted and supplied with all necessary meters and apparatus.—*L'Electricien* (Paris), June 28.

Selection of Tramway Motors—Tractive Effort and Power Required.

In this article Mr. Harold C. King discusses the selection and testing of tramway motors. It is important in selecting motors that full data of the work they have to do be given, such as weight of cars, average maximum loads, schedule speeds, number of stops, etc. The principal elements of the duty a motor has to perform are: (*a*) The general cycles of variations of power required giving the continuous or intermittent requirements, also its average during continued service operation; (*b*) the maximum output of power required determining the maximum current required. For suburban and interurban traffic a high-speed motor is required, and for town and city work, where stops are frequent, it is most essential to have motors with quick accelerations. It is much more desirable to have non-uniform rate of acceleration than uniform. With a uniform rate of acceleration, the mean acceleration can average a very high limit with perfect comfort to passengers. Sufficient attention in the past has not been paid to the question of acceleration. The practice has been to aim at a high-speed motor, which is unnecessary, better results being obtained with high-rate accelerations. For maintenance purposes it is desirable to obtain a motor with the lowest armature speed. Another point which is important is the pairing of the motors. This test is very necessary where there are heavy gradients to contend with. A method which may be used for the pairing test is: The two motors are connected together either with a common gear-wheel or direct-coupled. The motors should be connected in series electrically so as to drive the connecting gear in the same direction, and sufficient voltage applied to the two motors to run them up to normal speed with the full load current. If it is found that the voltage is not evenly divided between the two motors, they are not well suited to run in pairs. Measurements should be made with a differential voltmeter or two voltmeters suitably connected to the terminals of each of the motors. This difference should not exceed ten per cent. Tests of the motors should be made when loaded up to their full capacity. For quickly ascertaining the power required for various weights of cars running at specified speeds on various gradients, a diagram is given, graphically setting forth all information pertaining to any conditions of service. The use of this diagram is explained and illustrated.—*The Tramway and Railway World* (London), June 12.

The Manufacture and Uses of Sodium.

Attempts to make sodium from its cheapest compound, the chloride, have thus far apparently been unsuccessful, owing chiefly to the high melting point (800 degrees centigrade) of the chloride and to its corrosive action when in the molten state. The process described involves the electrolysis of sodium nitrate, with the liberation of sodium and of nitrogen peroxide, which is then converted into nitric acid. The decomposition cell consists of a cast-iron pot set in a brick furnace. At the bottom of the pot is a six-inch layer of refractory insulating material, and on this rests a cup thirty inches high and sixteen inches outside diameter, with walls four inches thick. This cup is made of two sheets of perforated steel, between which is a mixture of ground dead-burned magnesite and Portland cement, which has been mixed with water and allowed to set hard. The space between the cup and the pot is filled with sodium nitrate, and the cup itself with melted caustic soda. The cast-iron pot acts as the anode, and five per cent of the current is advantageously shunted through the metal walls of the cup. The cathode consists of a short length of four-inch wrought-iron pipe, reaching nearly to the bottom of the cup. Each furnace takes a current of about 400 amperes at an average electro-motive force of fifteen volts. An external heat is used only when starting up or when changing the cups, which have a life of from 425 to 450 hours. When the current is passed, nitrogen peroxide and oxygen are liberated at the anode and escape through a hole in the cover of the pot. Sodium is liberated at the cathode and rises to the top of the cup, where, at intervals of an hour, it is dipped off with a spoon and preserved under mineral oil. The aim of this new process is to decompose sodium nitrate in such a way that the sodium is liberated in a medium which will not oxidize it, and to get the nitrogen peroxide for the manufacture of nitric acid. — *Nature* (London), June 19.

A Simple Form of Fuel Calorimeter.

The apparatus consists essentially of a jar-like receptacle inside of which a circular plate is supported on three brass legs. A thin-walled brass tube about one inch in diameter passes from the centre of the circular brass plate and is continued to a chamber composed of two flat brass plates screwed together, the upper plate being hollowed out and perforated with numerous fine holes. A recess turned in the circular brass plate contains a rub-

ber ring, and a glass cover, furnished with a ground flange at one end and terminating in a neck at the other end, rests with its flange on the rubber ring. This is held in position by means of a brass ring which is screwed down on to the flange by means of milled nuts, a second rubber ring being placed between the circular plate and the glass flange, making a perfectly air-tight joint without danger of cracking the glass. The upper part of the thin brass tube terminates in three flexible brass tongues, which serve to hold a porcelain or platinum crucible in which the sample for testing is burned. The neck of the flask is fitted with a rubber cork, through which are passed thick copper wires, these being connected in the crucible with a thin piece of platinum or iron wire, so as to form an electric ignition. Through the centre of the cork a piece of glass or metallic tubing is passed, reaching to the level of the rim of the crucible. The oxygen used in the combustion is delivered through this tube. An average sample of coal or coke is ground up in a mortar, and one to one and one-half grammes are weighed out in the crucible, which is then fixed in position. The cover is placed over the crucible and screwed down so as to make an air-tight joint, and the cork with its connections inserted in the neck. A gentle stream of oxygen from a cylinder or gas-holder is then turned on, and the apparatus immersed in a known quantity of water contained in the receptacle. The temperature of the water is now taken with a delicate thermometer, and ignition commenced by passing a current of electricity through the wires. As soon as combustion commences the battery is disconnected, and the burning continues in the stream of oxygen. The escaping hot gases are compelled to pass down the thin-walled tube into the chamber made by the two flat brass plates, out of which they escape in extremely small bubbles which rise and rest for a time on the under surface of the circular brass plate, finally escaping around the sides. This arrangement ensures that all the heat carried over from the combustion chamber by the gases is imparted to the water before the bubbles reach the surface. When combustion ceases, the oxygen is allowed to continue passing through until no further rise of temperature is observed. When the previously hot crucible will have been cooled down to the common temperature, the thermometer is read, after mixing the water, and the calculation made. If a Fahrenheit scale is employed, the result will be equivalent to the number of British thermal units given out per pound of coal burned. If a centigrade thermometer is used, the result will be expressed in pound-degree-centigrade heat units per pound of fuel.—*Engineering* (London), June 20.

The New Shoreditch Electricity Works.

The new power station of the Metropolitan Bureau of Shoreditch, Haggerstown, England, recently inaugurated, occupies a site of about 19,800 feet in area. The boiler house plant consists of four water-tube boilers of the Babcock & Wilcox marine type. Each boiler has a heating surface of 2,720 square feet, and is fitted with economizers containing 350 square feet of heating surface, making a total heating surface in the four boilers of 10,880 square feet, and in the four economizers of 1,400 square feet, giving a total heating surface in the four boilers and four economizers of 12,280 feet. Three of the boilers are hand-fed, having an ordinary grate area of 73½ square feet. The remaining boiler is fitted with a double four-foot patent chain grate stoker. The grate area of this boiler is 68 square feet. These four boilers, combined, will produce about 50,000 pounds of steam per hour, and are arranged along one side of the boiler house, the space on the opposite side of the boiler house being available for the accommodation of additional boilers whenever they are required. The products of combustion are led from the boiler to the chimney through flues constructed of steel plates. A chamber has been provided at the base of the chimney shaft to which the main flue is connected, and is so arranged that induced draft apparatus can be added subsequently. The boilers are supplied with coal from an overhead store, having a capacity of 750 tons. The coal is lifted from barges by means of a hinged grab or shovel of a half-ton capacity. The hoist operating the shovel is driven by means of two electric motors of the enclosed type, the speed of each being regulated by a series parallel controller. Each of the openings at the bottom of the coal-box is provided with regulating valves, one being placed opposite the centre of each boiler, which enables the flow of coal to be controlled. The coal is delivered by means of these valves into a hopper having a weighing apparatus, so as to correctly register the amount of coal delivered to the boilers. The engine house plant consists of two vertical slow-speed compound Corliss steam engines, direct-coupled to a continuous-current dynamo of 800-kilowatt capacity. Each engine is provided with its own condensing plant, consisting of surface condenser with air and circulating pump driven direct from the main engine. The engines are designed to run at a speed of ninety revolutions per minute, and are capable of developing from 1,300 to 1,400 indicated horse-power. The diameter of the high-pressure cylinder is 24½ inches, and the diameter of the low-pressure cylinder is 53 inches; the stroke, 42 inches. The crank shaft, generator bearings, connecting rod ends and slides are provided with forced lubrication under pressure, oil pumps being provided for this purpose, working from the crank shaft. The generators are of the multipolar type. The armature and commutator are built upon a ventilating cast-iron sleeve forced on the engine shaft under pressure. The field castings are divided in a vertical plane and are mounted on cast-iron sole-plates. The graded load of each of the machines is 730 amperes and 1,100 volts, being designed, however, to carry an overload of fifty per cent for two hours. The armature is of the slotted drum type, having a multiple winding so arranged that the circuits will not become unbalanced by a slight displacement of the armature from the centre of the fields. The exhaust steam from each engine passes through an oil separator to the condensers, which have a cooling capacity of 2,700 square feet. The switchboard is placed in a gallery which runs the whole length of the engine room, the high-tension portion being placed at one end, and the low-tension portion at the other. The high-tension board is divided into sections, as follows: High-tension dynamo board, comprising positive and negative dynamo panels for each generator, with paralleling panel in the centre; high-tension trunk feeder board, comprising positive and negative panels for two feeders; high-tension transformer board, comprising panels for four transformers; and the arc circuit board, with provision for three arc circuits. The low-tension board consists of positive and negative feeder panels for six low-tension feeders. The switchboard will be used in connection with the continuous-current transformers and for supplying the network in the neighborhood of the station, and is arranged with the plugged system, whereby any transformer can be plugged on to any low-tension feeder.—*The Electrical Engineer* (London), June 20.

INDUSTRIAL SECTION.

ILLUSTRATED DESCRIPTIONS OF NEW AND STANDARD ELECTRICAL AND MECHANICAL APPARATUS.

The Nernst Lamp.

The Nernst lamp is a new form of incandescent lamp, and derives its name from its inventor, the eminent German scientist, Doctor Walther Nernst. The distinguishing features of the Nernst lamp are its filament or glower, and the means for making the glower conductive. The glower operates in the open air, and its removal and replacement may be readily accomplished. It is a non-conductor of electricity at ordinary temperatures, and a heater is provided for giving an initial temperature sufficient to make it conductive. When it becomes conductive by external heat, the current traversing the glower not only causes it to emit light, but also to develop internally sufficient heat to maintain it in a conductive condition, the action of the preliminary heater being discontinued.

FIG. 1.—THE HEATERS AND GLOWERS.

The accompanying illustrations show some of the parts of the Nernst lamp in detail, and also the finished appearance of the lamp when ready to be set up. Fig. 1 shows the heater tubes and glowers. The glower is the light-giving element of the Nernst lamp. The standard 220-volt glower is about 25 millimetres long and 0.63 millimetre in diameter. This is made by pressing from the die a dough made of the rare earths mixed with suitable binding material, cutting the porcelain-like string thus made into convenient lengths, drying, roasting, and finally attaching lead wires. The heater is made up of two or more small white porcelain tubes about the size of a lead pencil. These have been wound with fine platinum wire, and in turn covered with a refractory paste, which protects the wire from the intense heat of the glower. These tubes are mounted on the heater porcelain, which constitutes a part of the holder and are wound for 110 volts and are mounted in pairs of two in series, according to the service, the one, two and three-glower lamps taking one pair, and the six-glower, two pairs. These heater tubes are mounted on a porcelain support in such a manner as to afford easy access for repairs without removing the glowers. The life of the heater, when running continuously, is about 200 hours, or about 133 hours when the current is turned on and off 4,000 times at regular intervals. Inasmuch as the heater is not called into service for more than about thirty seconds to light the glowers, this would indicate a practically unlimited life. In actual service, however, the heater remains in close proximity to the glower, and the high temperature to which it is subjected causes a material decrease in its life. Nevertheless, the life of the heater is surprisingly long — probably several thousand lamp-hours.

The advantage to be gained by the use of a steadying resistance which would enable the glower to be operated efficiently at or beyond the crest of a characteristic wave has been recognized, and to accomplish this end under all conditions of commercial use, and with as little loss as possible under normal conditions, a steadying resistance should have as large a positive temperature correction as possible, and this temperature correction should always be immediately available. For example, if the glower were operated on or beyond the crest of the characteristic wave, the current could obviously be controlled by a sufficiently large steadying resistance having no temperature correction, but such resistance would very materially decrease the efficiency of the glower. On the other hand, if the resistance is assumed to have a high temperature coefficient, the necessary steadying resistance under normal conditions may be very much less than when no temperature correction is present, and then should there be an increase in electro-motive force above normal, the corrective power of the steadying resistance would be brought in play to check any abnormal flow of current through the glower—in other words, to take up the additional voltage. A steadying resistance or ballast has been designed, which is certainly unique in construction, and which meets in a very effective manner the peculiar requirements of the glower. Iron wire is used on account of its high temperature correction, and by properly mounting this in a small glass tube filled with some inert gas, a ballast has been secured having at once a high corrective power with minimum resistance under normal conditions, and oxygen being entirely excluded, the wire can readily be worked throughout the entire high corrective region without danger of destruction. The diagram of the connection of this ballast is shown in Fig. 2.

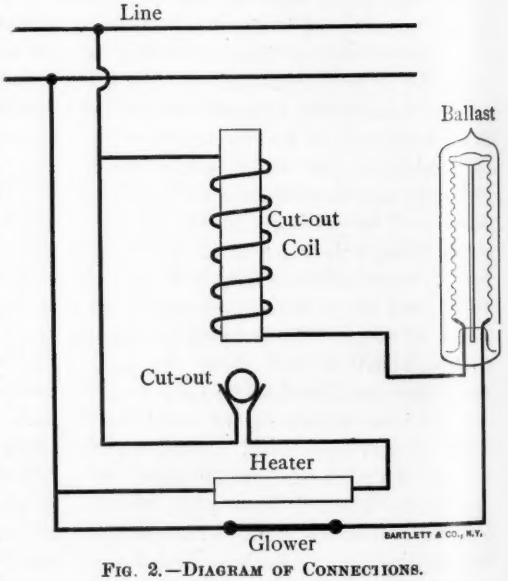


FIG. 2.—DIAGRAM OF CONNECTIONS.

An automatic lamp requires a cutout to disconnect the heater from the circuit as soon as the glower shall have lighted. The cutout includes the coil, a moving member, and a contact, all of which must function at a temperature of 110 degrees centigrade without possibility of failure. The coil must therefore be heat-proof, the contact must not weld, and the moving member should not hum on alternating currents. These require-

ments are severe, but they have all been met in a most effective and satisfactory manner by embedding the coil in cement, and making a contact of silver, and by suspending the moving member from a single point of support.

The main features of the Nernst lamp are the same in all types. The indoor lamps are provided with ornamental spun-brass houses, and the outdoor lamps with neat japanned cast-iron houses. Single-glower lamps have single-pole cutouts, while all the multiple glower lamps are provided with double-pole cutouts, the reason for this difference being that the extremely high temperature in the immediate neighborhood of a number of glowers tends to establish leakage currents between the glowers and heaters unless the latter

FIG. 3.—THE SIX-GLOWER INDOOR TYPE, WITH HOUSING REMOVED.

be entirely disconnected from the circuit.

Fig. 3 shows the six-glower indoor type of Nernst lamp, with housing removed; and Fig. 4 a thirty-glower indoor type. The six-glower lamp is typical of all the others. This lamp is suspended from an eyebolt which, being removed, allows of immediate access to the inner parts. On removing the housing, the

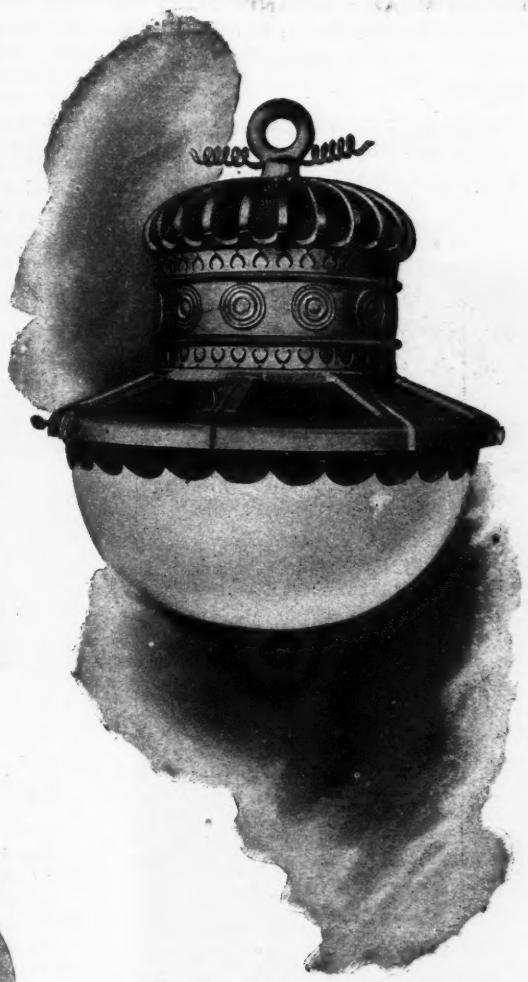


FIG. 4.—THE THIRTY-GLOWER INDOOR TYPE.

ballasts are found placed in a semi-circle around the cutout, the arrangement of the parts being such as to make all easy of access. The connections are made with small aluminum plugs on the interconnecting wires, which avoids any inconvenience involved by the use of set screws. All of these parts are mounted on porcelain. The heaters or glowers are attached to the removable piece or holder, the design being such that the heaters, backed by a porcelain disc, are immediately above the glowers, resulting in advantages of the stagnation of heat from the heater lighting the glowers in minimum time; there are no shades, nearly all of the light being thrown downward, where it is ordinarily most desired; stagnation of heat from the glowers, whereby the latter are run in their own heat, and therefore at a higher efficiency than would otherwise be secured. The holder is provided with nine contact prongs which, when the holder is pushed into the lamp, automatically make the desired connections. Fig. 5 shows the relative position of the different parts in detail.

For a given illumination, it is stated that the Nernst lamp requires only about one-half the amount of electrical energy required by ordinary incandescent lamps, and about the same as that of the enclosed arc lamp. The following four sizes have been perfected: the one-glower, at 86 watts; the two-glower, at 176 watts; the three-glower, at 264 watts; and the six-glower, at 528 watts; or about 88 watts per glower. Each glower is equal in candle-power to three ordinary sixteen-candle-power incandescent lamps, the proportion of the glowers to light being nearly constant. The lamp possesses great advantages for many purposes, the soft white light making it possible to do better and more efficient work in shops, and its operation on alternating-current circuits for all frequencies without flickering. One of its greatest advantages is claimed to be the superior quality of its light for the correct determination of color, which feature is believed to be of incalculable value in places where quality of light is important, as in silk and cotton goods, tobacco factories, coffee houses, art galleries, etc.

The Nernst Lamp Company, of Pittsburg, Pa., is the manufacturer of this

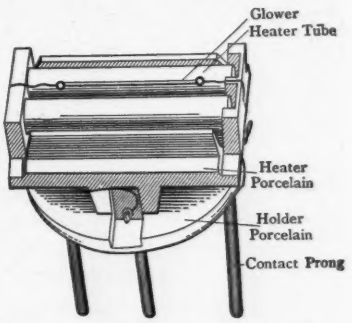


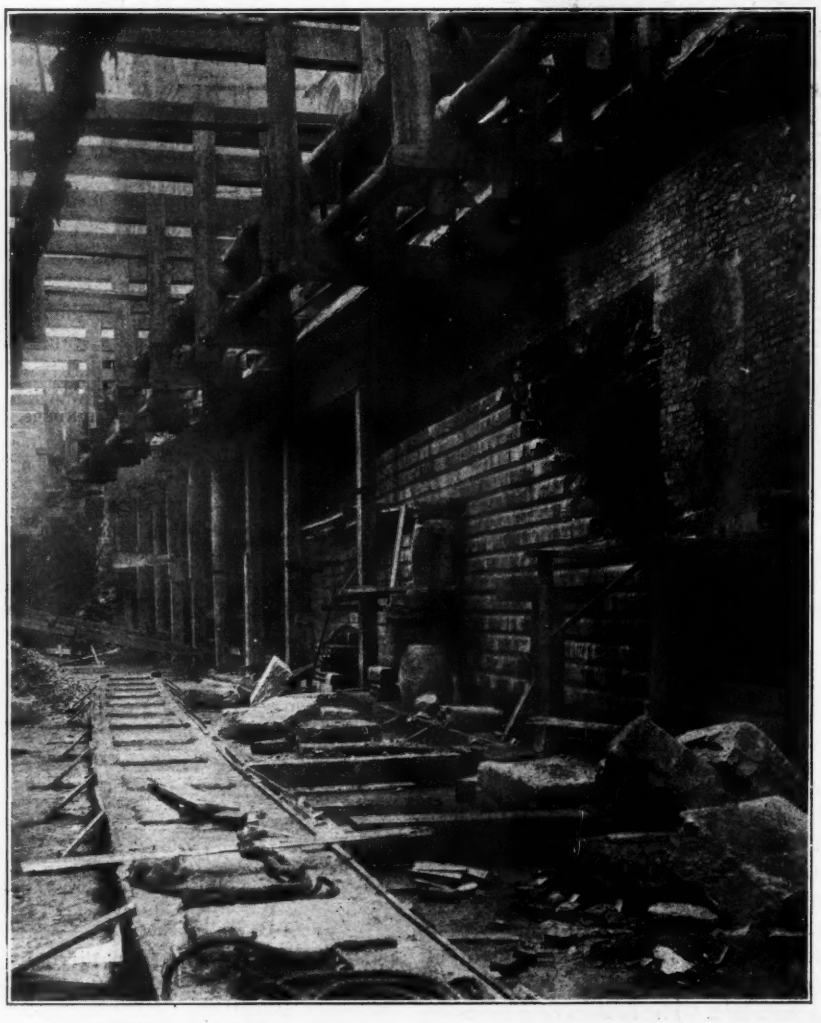
FIG. 5.—DETAIL OF LAMP FITTINGS.

lamp. Mr. Calvin S. Rice, recently with the Edison Illuminating Company, New York, is the vice-president and manager of the company.

The lifting power of any gas is the difference between the weight of the gas and the weight of the same volume of air. One cubic foot air at normal pressure weighs 1.29 ounces avoirdupois; one cubic foot pure hydrogen under the same conditions weighs 0.089 ounce avoirdupois. The difference is 1.2 ounces, which is the weight that one cubic foot of hydrogen will balance in the air. It will lift any weight less than that.

The Vitrified Conduit System in the New York Rapid Transit Subway.

The illustration shown herewith is a view on Fourth avenue, between Ninth and Tenth streets, of the underground subway system now in course of construction for rapid transit service. The picture shows interestingly the method by which the conduits for electric wires and cables are being constructed. The portion of the conduit system shown here is



THE CONDUIT CONSTRUCTION IN THE NEW YORK RAPID TRANSIT SUBWAY.

only partially completed, as the plans call for the laying of conduits to the top of the subway, 128 conduits of the four-multiple type being used to complete both walls of the tunnel. It is said that the method of disposing of the conduit system in the subway was one to which the engineers gave much study. The conduits shown here were designed and manufactured under the personal supervision of Mr. R. W. Lyle, president and manager of the Standard Vitrified Conduit Company, of New York, and Mr. B. S. Barnard, vice-president and secretary of that company.

Change in By-Laws of the National Electric Light Association.

At the Cincinnati convention of the National Electric Light Association the following amendment to the by-laws, relating to the membership dues, was adopted:

ARTICLE VII—Dues—After January 1, 1903, all new members shall pay an entrance fee of $25. The annual dues of members in cities or towns of less than 20,000 population shall be $10; the dues of members in cities or towns of from 20,000 to 300,000 population shall be $25, and the dues of members in cities or towns of over 300,000 population shall be $50. These dues shall be payable in advance and shall cover the calendar year. Any member in arrears for one year's dues shall be dropped from the rolls, and if he is reinstated he shall pay his dues for the time during which his membership lapsed, or shall be required to pay again the entrance fee of $25.

It is announced that for the remainder of the year 1902 new members from towns of less than 20,000 population will be received in full membership upon payment of $10 dues.

Among the new members added since this change was made are the following:

Albert Lea, Minn.—Albert Lea Light and Power Company.
Altoona, Pa.—The Edison Electric Illuminating Company of Altoona.
Anaconda, Mont.—Anaconda Copper Mining Company, electrical department.
Atlantic City, N. J.—The Atlantic Electric Light and Power Company.
Auburn, N. Y.—Auburn Light, Heat and Power Company.
Bloomington, Ill.—Bloomington & Normal Railway, Electric and Heating Company.
Clay Center, Kan.—F. L. Williamson & Company.
Clinton, Ill.—Clinton Gas Company.
Edwardsville, Ill.—Edwardsville Electric Light and Power Company.
Columbus, Ga.—Columbus R. R. Co.
Covington, Ky.—Union Light, Heat and Power Company.
Durango, Col.—C. H. Peters.
Evansville, Ill.—Evansville Gas and Electric Light Company.
Elizabeth City, N. C.—Elec. Light Co.
Fair Haven, Vt.—Fair Haven Elec. Co.
Fishkill-on-Hudson, N. Y.—Citizens' Railroad, Light and Power Company.
Fulton, N. Y.—Fulton Light, Heat and Power Company.
Jackson, Mich.—Jackson Light and Power Company.
Lancaster, Ohio—The Lancaster Electric Light Company.
Lead, S. Dak.—Belt Light & Power Co.
Mason City, Iowa—Brice Gas and Electric Company.
Macon, Mo.—Northwestern Electric Heat and Power Company.
Manheim, Pa.—Lancaster Valley Electric Company.
Menomonie, Wis.—Menomonie Electric Light and Power Company.
Middlebury, Vt.—Middlebury Elec. Co.
Montpelier, Vt.—Consolidated Elec. Co.
Muscatine, Iowa—Citizens' Railway and Light Company.
New Albany, Ind.—United Gas and Electric Company.
Nokomis, Ill.—Nokomis Electric Light and Power Company.
Norwich, N. Y.—Norwich Gas and Electric Company.
Nyack, N. Y.—Rockland Light and Power Company.
Plymouth, Mass.—The Plymouth Electric Light Company.
Red Oak, Iowa—Red Oak Elec. Co.
Red Wing, Minn.—Red Wing Gas and Electric Company.
Rockford, Ill.—Rockford Edison Co.
Rutland, Vt.—Rutland City Elec. Co.
Scranton, Pa.—Scranton Illuminating, Heat and Power Company.
Tuxedo, N. Y.—Tuxedo Elec. Light Co.
Wabash, Ind.—The Wabash Electric Light Company.
Watertown, N. Y.—The Watertown Electric Light Company.
Wheeling, W. Va.—Wheeling Elec. Co.
Zanesville, Ohio—Zanesville Electric Light Company.

Variable Speed Machine-Driving Motors.

The growing application of small motors to the driving of machine tools has made necessary a study of construction conditions which will satisfy a demand for a motor which will stand up under a wide range of work, particularly one which can take excessive loads without undue heating, and which will have a wide variation of speed with little or no changing of the brushes. From time to time motors have been placed upon the market embracing conditions which, for some particular branch of service, make them peculiarly adapted. The question of range of speed adjustment of more than 100 per cent, with sparkless commutation, has been one that has given designers no little labor to perfect.

In the accompanying illustrations are shown the sectional diagrams and several applications of an enclosed motor of a distinct construction, which is claimed to satisfy every condition called for in machine-driving service. A typical motor is shown in Fig. 1. Referring to Fig. 2, the centre pole, C, and external shell, S, are cast in one piece, and the two end poles, E, are connected to each end of S by an invisible joint, J, extending around the circumference of the shell. These enclose and protect the field coils, F. These coils surround, and in turn are surrounded by magnetic frames, C, S and E. Hence all magnetic lines produced by the exciting coils are received by the steel at a minimum distance from the coil. The coils, F, are so connected that the centre poles, C, are of one polarity, that is, north; and the end poles, E, are of south polarity, leaving the armature as the most direct means by which the magnetic lines can close. By this method of field excitation there is practically no external magnetism and the internal leakage is reduced to a minimum, and it is claimed there is no so-called magnetic lag.

The bearings for the armature shaft

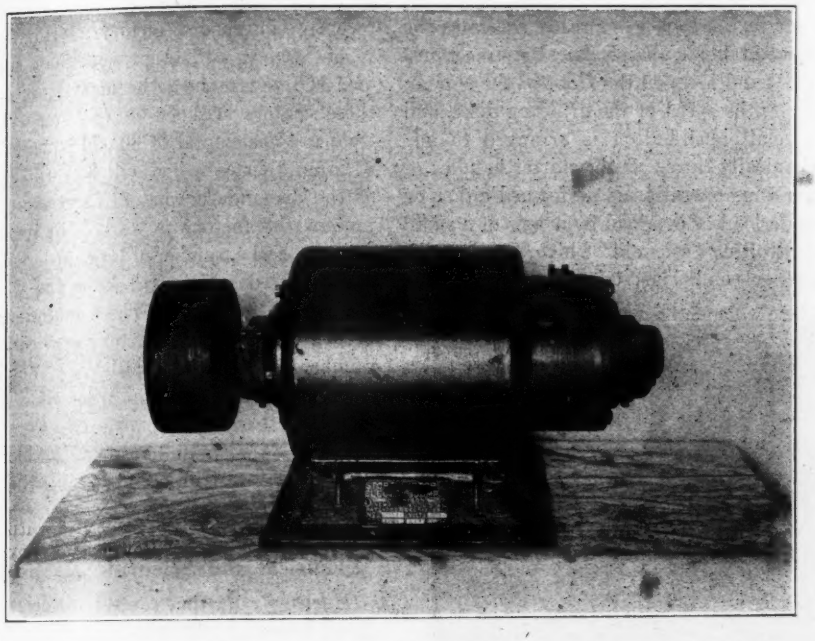


FIG. 1.—ENCLOSED MOTOR FOR DRIVING MACHINE TOOLS AT VARIABLE SPEEDS.

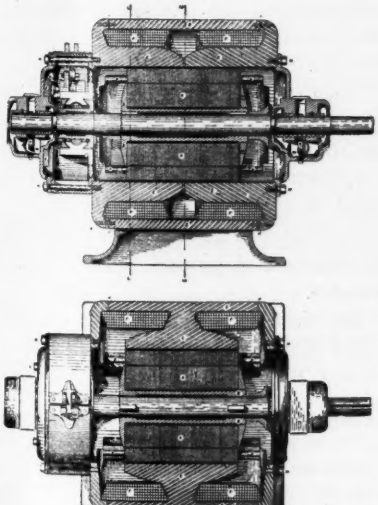


FIG. 2.—CONSTRUCTION DETAILS OF VARIABLE SPEED MOTOR.

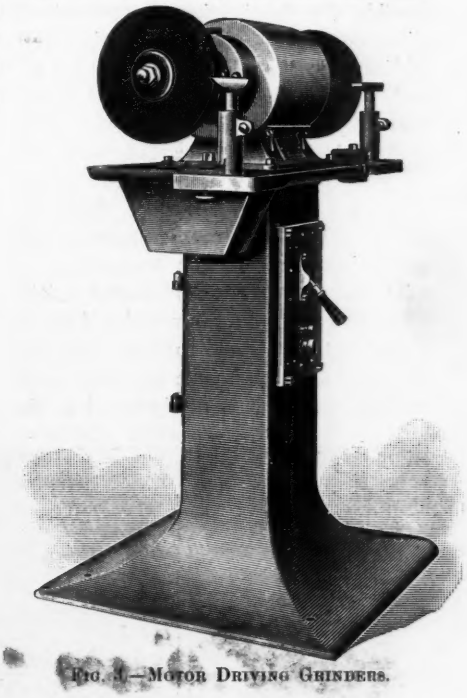


FIG. 3.—MOTOR DRIVING GRINDERS.

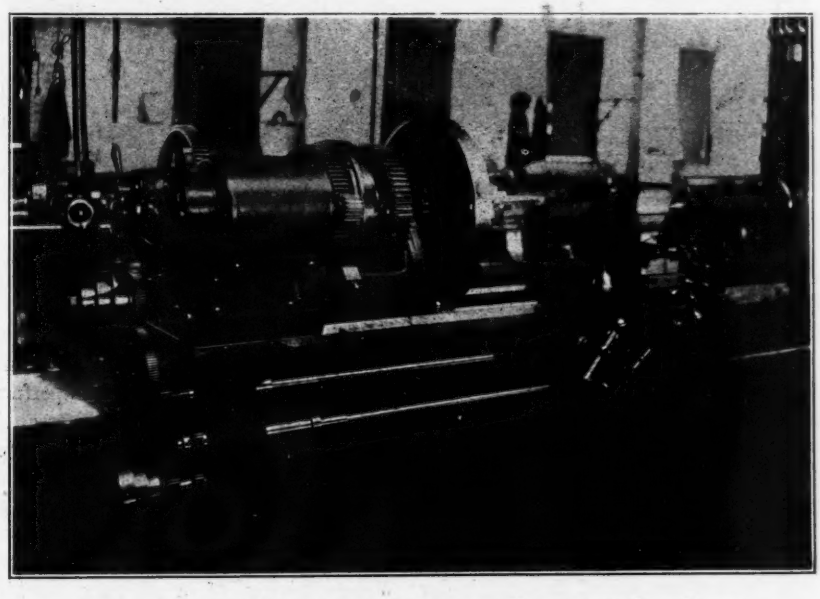


FIG. 4.—ENCLOSED MOTOR DIRECT-COUPLED TO TWENTY-NINE-INCH LATHE.

are flanged and fit perfectly into the core of the magnetic frame, and are held rigidly in place by bolts, H, making it impossible for the bearings to be out of alignment. The shaft is continuously lubricated by the oil ring, R, from the oil well, W. The bolts, H, are placed ninety degrees apart, so the bearings may be shifted 90 or 180 degrees, and the machine run equally well whether on the floor, side wall or suspended from the ceiling. The armature is drum-wound, and is made up of thin laminations of mild sheet steel deeply slotted. The armature cores are form-wound and taped, placed in the slots and banded. The core discs are assembled on a separate sleeve or bushing, which is firmly keyed to the shaft and may be removed by disconnecting the commutator without disturbing the winding.

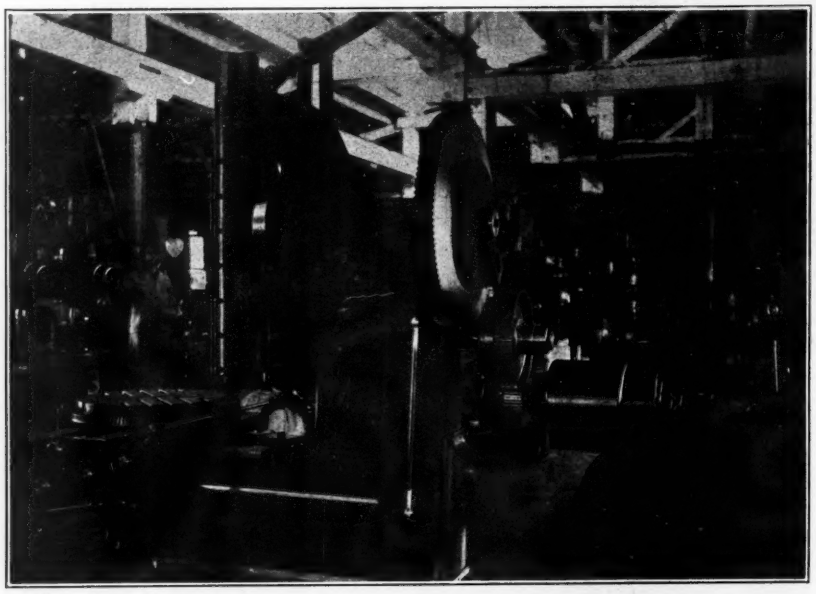


FIG. 5. THREE-HORSE-POWER MOTOR DRIVING SLOTTING MACHINE.

This machine is entirely enclosed and can be used advantageously under very severe service conditions. The manufacturer claims that it has given good service and has been run for long periods in such installations as milling work and under atmospheric conditions where nothing but an enclosed motor could stand up.

The motors are all of the multipolar type and are made in sizes from one-half horse-power to fifty horse-power. They are designed for use on buffing lathes, disc grinders, grinding machines, tool grinders, etc. The manufacturer makes a specialty of designing machines for the direct driving of motors with variable speeds. The speed variation is controlled entirely by a field rheostat, either on the motor-starter switchboard or on the machine, the location being that which would be of the greatest convenience to the operator. Figs. 3, 4 and 5 show the application of this motor to machine tools in the factory where it is built. Fig. 3 is a side view of a grinding motor on floor column, with underload and overload starting rheostat and push-button stop. A door in the back gives ready access to the rheostat and all electrical connections. The hand lever on the front of the column varies the speed of the grinding discs, and a small push-button is arranged to mechanically throw off the starter handle; or the same operation is performed either on underload or overload by means of a small controlling solenoid which, under the proper conditions, trips a small trigger, when the spring carries the starter handle back to the off position.

Fig. 4 shows the application of a three-horse-power motor to a lathe with twenty-nine-inch swing. This motor is performing daily a service which requires an increase of speed of from 100 to 200 per cent, it being entirely controlled by the field rheostat without change in the adjustment of the brushes. Fig. 5 shows a three-horse-power motor applied to the direct driving of a slotting machine. In a factory test, the speed of this machine was varied from 600 revolutions, with 1.45 amperes at 110 volts in the field, to 2,400 revolutions, with 0.21 ampere in the field. The speed was then jumped to 2,600 revolutions, the range of stroke in all being varied from six to thirty per minute. There was no visible sparking, and during the entire change the brushes were not in any way shifted. The machine is normally run at a variation of from 100 to 200 per cent under shop conditions, and the manufacturer states that a careful efficiency test has shown that this type of motor has produced regularly an average of ninety-one per cent.

The Storey Motor and Electric Company, the manufacturer of this motor, has recently equipped a factory at Harrison, N. J., where, with a present floor space of 1,700 square feet, the manufacture of these motors will be carried on. The company has a total of 60,000 square feet of ground space which will be built upon as the demand for motors increases. At present the factory is worked to its full capacity, and a number of large orders have been secured which will keep the works busy for a long time. These motors have been giving very satisfactory service in a number of difficult installations, notably that of the Metropolitan West Side Elevated Railway Company, of Chicago, where a large number of these motors have been installed for operating the air compressors since 1895.

Electrical and Scientific Meetings.

Meetings of the several associations given herewith will be held as follows:

New York State Independent Telephone Association, Rochester, July 23 and 24.

American Electrotherapeutic Association, Hotel Kaaterskill, Catskill Mountains, N. Y., September 2, 3 and 4.

New York State Street Railway Association, Caldwell, N. Y., September 9 and 10.

Association of Edison Illuminating Companies, White Mountains, September 9 to 11.

American Electrochemical Society, Niagara Falls, N. Y., September 15, 16 and 17.

Indiana Electrical Association, Indianapolis, September 17 and 18.

International Association of Municipal Electricians, Richmond, Va., October 7, 8 and 9.

American Street Railway Association, Light Guard Armory, Detroit, Mich., October 8, 9 and 10.

Addresses Wanted.

TO THE EDITOR OF THE ELECTRICAL REVIEW:

Will you kindly furnish me with the addresses of the various makers of thermopiles, such as Clammond, Gulcher, Cox, etc.

J. B. STRAUSS,
97 Washington street,
June 27. Chicago, Ill.

CURRENT ELECTRICAL NEWS

COMMERCIAL NEWS

DOMESTIC AND EXPORT

HAVANA FRANCHISES—Concessions said to be worth $25,000,000, and including all the franchises of the city of Havana, have been let to Messrs. Park and Hamilton, of Youngstown, Ohio. These franchises authorize the construction and operation of electric street railway lines throughout the city of Havana, commencing at a point where all steamers land and running through the heart of the city.

A LARGE INCREASE IN CAPITAL—The New Orleans Railway Company has increased its capital stock from $5,000,000 to $40,000,000, consisting of $30,000,000 common and $10,000,000 preferred stock. In addition, the company will issue $40,000,000 of four and one-half per cent sinking fund mortgage bonds. This syndicate recently formed the consolidation of all the street railway and electric lighting companies of New Orleans.

A BRITISH CONTRACT TO BE LET—The Yorkshire Electric Power Company, a British corporation, is about to let some large contracts for electrical equipments to be installed in four long-distance generating stations. It is anticipated that the capacity of the plants in the aggregate will be eventually over 300,000 horse-power. The initial plant will consist of four 1,250-kilowatt units and two 2,500-kilowatt units, making in all 15,000 horse-power. Of the first instalment of plant there will be a supply of 5,000 kilowatts, direct current, for use within a radius of three miles of the power station. The remainder of the plant will be of three-phase type. Two American concerns are said to be figuring on the contract.

BALTIMORE ELECTRICAL DEAL—It is announced that a deal which has been pending for over a year has been closed in Baltimore, involving the United Electric Light and Power Company and also the Mount Washington Electric Light Company. A syndicate, in which it is said New York as well as Philadelphia and Baltimore capital is interested, has been organized under the financial direction of the Continental Trust Company of Baltimore, to absorb the light and power companies and develop a plant and works on the Susquehanna River. The price paid by the syndicate for the two lighting and power companies is about $900,000. It is said that the Susquehanna company will have three plants of 40,000 horse-power each.

NEW JERSEY TROLLEY MERGER—In order that the management of the Johnson trolley syndicate in the East may be controlled with more ease than formerly, the Trenton, Lawrenceville & Princeton, the Princeton Street Railway, the Yardley, Morrisville & Trenton, and Newton & Yardley street railways have been consolidated with the New Jersey-Pennsylvania Traction Company, which concern controls the Lehigh Valley lines in Pennsylvania. Each line will maintain its original individuality, although the officers become subordinate to the directorate of the New Jersey-Pennsylvania company. The company will raise its capital from $1,000,000 to $3,000,000, and Jilson J. Coleman, who has for a long time been in charge of the Johnson lines, will be president of the directorate.

ONTARIO POWER COMPANY ACQUIRES NEW RIGHTS—The Ontario Power Company states that rights have recently been acquired which will enable it to develop 400,000 horse-power. An agreement has been reached with the Canadian park commissioners whereby the right to tap the Niagara River at the Dufferin Islands has been obtained. The company now has the right to take water from the Welland River, and it is working on this. The new right allows the company to develop twice the original amount of 200,000 horse-power. It is understood that a contract for machinery to develop 50,000 horse-power will shortly be let. The company expects to supply power in Buffalo and Toronto, as well as to have some at Niagara Falls, Ontario. The power-house will be located below the bank near Table Rock, and it will carry its waters in a canal from the source to the power-house, save where it tunnels the high bank.

WIRELESS TELEGRAPH TESTS—The Naval Department, Washington, D. C., has in contemplation a plan to establish a wireless telegraph station in San Francisco Harbor. The department now has no adopted system of wireless telegraphy, but expects soon to begin a series of experiments at different points with foreign systems. Lieutenant Hudgins, of the Naval Bureau Equipment, sent abroad to purchase apparatus for trial, has left Germany for New York, bringing with him the apparatus of two French and two German systems of wireless telegraphy, and these will be tried with the Marconi system at New York, Indianapolis, Washington, San Francisco and other points. The operators in charge of the expedition to Alaska, where a line from Fort Gibson to Bates Rapids is to be established for the United States Signal Service, are en route to Seattle. The material for the Alaskan line of communication, which is about 180 miles long, accompanies the operators, and is expected to be in service condition by October 1.

TROLLEY LINE TO JERSEY CITY—At a recent meeting of the Rapid Transit Commissioners of the city of Greater New York, the committee reported favorably on the application of the New York & New Jersey Railroad Company for a franchise to build a tunnel under the North River with a terminal in New York city. The company proposes to construct and operate a road for the transportation of passengers and property, with two tracks betwen New York and New Jersey. The necessary property for the terminal is to be purchased at the expense of the company, which has agreed to begin construction within three months after obtaining the necessary consents and to have the road in working order within three years. Under a schedule compiled by the committee, the company is to make annual payments for the right to enter the city within the pier line and have underground portions of the street at a rate of $14,386 for the first ten years, and for the next fifteen years at the rate of $25,673. At the end of twenty-five years the charges are to be readjusted, and thereafter at intervals of twenty-five years. If the city and company can not agree upon the rates at the time of readjustment, these are to be determined by the Supreme Court. The company is to pay the city for the first ten years three per cent and for the next fifteen years five per cent upon an estimate of its gross receipts from traffic within the city of New York. A rough estimate and the franchise fix this at $300,000 a year for the next twenty-five years.

TELEPHONE AND TELEGRAPH

CHAPPELL, NEB.—The Deuel County Telephone Company has completed a line from here to Oshkosh and Lewellen, and the instruments will be immediately put in place.

MEXICO, MO.—The Mexico telephone system has been sold to R. V. Montague and other Kansas City men, and the lines are to be extended in this section of Missouri and greatly improved. Ten thousand dollars is to be spent for this purpose.

FREMONT, NEB.—The new Fremont Independent Telephone Company is soon to begin equipping its plant, and proposes to connect with the Farmers' Telephone Company, and also to extend lines into the country district surrounding Fremont not covered by other companies. Negotiations are already under way for connections with companies at Wahoo, Arlington and other places.

ALBANY, N. Y.—The National District Telegraph Company, of New York, with a capital of $150,000, has been incorporated. The general route in this state includes Poughkeepsie, Binghamton, Elmira, Buffalo and other towns and villages. The directors are Belvidere Brooks, of Montclair, N. J.; George H. Fearons, of West End, N. J.; Edward M. Mulford, John C. Barclay, Charles H. Bristol, Francis R. Stark and Albert T. Benedick, of New York city.

NORWALK, OHIO—The formal transfer of the entire stock of the Huron County Telephone Company and the Attica Telephone Company to the Local Telephone Company has taken place. Mr. J. F. Laning, of Norwalk, is president of the new company, and Mr. C. R. Callaghan, of Bellevue, general manager. The Norwalk exchange is being entirely rebuilt, and will commence operations with 600 telephones. The other exchanges are Milan, Berlin Heights, New London, Monroeville, Chicago Junction, Plymouth, New Washington, Attica and several others, all connected by their own toll lines. The company has already 4,000 telephones in operation.

PERSONAL MENTION

MR. W. S. SISSON, secretary of the D. & W. Fuse Company, Providence, R. I., was a New York visitor last week.

MR. C. W. HUNT, of the C. W. Hunt Company, accompanied by his family, is spending some weeks in Scotland.

MR. WILLIAM C. BANKS, of the Gordon Battery Company, New York, has made an extensive tour through the West.

MR. JACOB BUNN, of the Sangamo Electric Company, Springfield, Ill., was a guest at the Engineers' Club, New York, last week.

MR. H. B. KIRKLAND, of the American Circular Loom Company, of Boston, spent a few days at his New York office during the past week.

MR. S. FAHS SMITH, vice-president of the firm of S. Morgan Smith, York, Pa., has been in New York, at the Manhattan Hotel, during the past week.

MR. M. MARSHALL, president of the Marshall-Sanders Company, electrical manufacturer, spent a few days last week at the Waldorf Hotel, New York.

MR. THOMAS R. MERCEIN, secretary of the Northwestern Electrical Association, has returned from an extensive trip through England and the Continent.

MR. A. G. DAVIS, president of the Viaduct Manufacturing Company, of Baltimore, is spending the summer months at his summer camp at Lake George, N. Y.

MR. W. J. PHELPS, manager of the Phelps Company, of Detroit, Mich., returned to Detroit a few days ago after a stay of several weeks in New York and eastern cities.

MR. GEORGE M. EASTMAN, superintendent of the testing department of the Chicago Edison Company, and Miss Fay Wheeler, of Lansing, Mich., were married on July 2.

SENATOR ALDRICH, of Rhode Island, has resigned the presidency of the United Traction Company, of Providence, R. I. Mr. Benjamin A. Jackson has been appointed as his successor.

MR. GEORGE B. FRANCIS, of Providence, R. I., has severed his relations with the United Traction Company, of Providence, to join the organization of Westinghouse, Church, Kerr & Company at New York.

MR. CHARLES T. MALCOLMSON, who has acted as chief of staff of the Bureau of Power and Lighting of the Charleston Exposition, has been made superintendent of power and transmission for the St. Louis World's Fair.

MR. C. S. COLTON, who has been identified with the Cleveland office of the Westinghouse Electric and Manufacturing Company, has been made assistant to Mr. F. S. Drake, manager of the Union Electricitäts Gesellschaft, of Berlin.

MR. WM. S. HORRY sailed on the steamship Lucania for England a few days ago. Mr. Horry is electrical engineer of the Union Carbide Works, at Niagara Falls, the electrical features of which were recently described in the ELECTRICAL REVIEW.

MR. R. T. LOZIER has assumed the management of the selling organization of the Bullock Electric Manufacturing Company, with offices at Cincinnati. Mr. Lozier had previously been manager of the New York office of this company for several years.

MR. HENRY L. SHIPPY, treasurer of the John A. Roebling's Sons Company, of New York, is sending a neat souvenir to many friends in the electrical fraternity. This is in the form of a key "chainelette," and is sent with the cordial greetings of his company, endorsing the wish that everything under lock and key might be kept safe, and that that which is in the possession of the recipient may increase in value, and that which proves of annoyance may decrease.

MR. WILLIAM BURNLEY, manager of the Burnley Battery and Manufacturing Company, of Painesville, Ohio, sailed on the steamship Etruria for England on Monday of this week. Mr. Burnley will visit Liverpool, London, Leeds and English cities, also Dublin and Glasgow, and afterward make a tour of the Continent. The purpose of Mr. Burnley's trip is to arrange for agencies for the products of his company, as the export feature of the company's business has become an important factor in its growth.

RECENT CHANGES in the personnel of electrical companies are as follows: Mr. P. T. Dunn has been made superintendent of the Cincinnati, Georgetown & Portsmouth Railroad Company, Cincinnati, Ohio; Mr. Edward Wolfe has been made chief engineer of the municipal plant at Greenfield, Ind., succeeding Mr. George H. Gant; Mr. Russell Baker has retired from the superintendency of the Electric Light and Water Company, Little Falls, Minn. This plant was recently acquired by the Morrison County Electric Light, Heat and Power Company.

THE MARRIAGE of Miss Lillian M. Kane, daughter of Captain John W. Kane, of Blue Hill, Me., and Mr. Frank L. Martin, of Chicago, occurred in the native town of the bride last week. The wedding was a charming social event, for which 300 invitations had been issued and for which unusually beautiful floral decorations nad been prepared. After the wedding reception Mr. and Mrs. Martin were driven to Ellsworth and left for Hancock Point, Me., where they will remain for a time. Mr. Martin is known in the telephone and publishing world as the head of the literary bureau for the Kellogg Switchboard and Supply Company, of Chicago.

OBITUARY NOTICE

DR. JOHN DANIEL RUNKLE, ex-president of the Massachusetts Institute of Technology, and Professor Emeritus of Mathematics in that college, died from heart disease at Southwest Harbor, Mount Desert, Me., on Tuesday, July 8. Dr. Runkle was born in Rome, N. Y., in 1823. He entered the scientific school at Cambridge in 1847, graduating in 1851. Because of his attainments both in mathematics and astronomy, he received an immediate appointment to the staff of the American Ephemeris and Nautical Almanac, with which he retained his connection until 1894. He was also instrumental in building up the *Mathematical Monthly*. About this time, when the Institute of Technology was projected, Dr. Runkle was active in interesting the public in the enterprise. He was a member of its first faculty, remaining so, except during the period when he was its president, as head of the mathematical department, until his retirement this year, when he was made professor emeritus. In 1868 he was elected acting president of the Institute, and in 1870 was elected president, serving in that capacity until 1878.

PROFESSOR JOHN BUTLER JOHNSON, dean of the College of Engineering of the University of Wisconsin, was instantly killed on June 23. He fell from a load of household goods that he was moving to his summer cottage and the wheel of the wagon ran over his head, crushing it. John Butler Johnson was born in 1850 on a farm near Marlboro, Stark County, Ohio. The family removed to Kokomo, Ind., in 1866, and he attended Howard College at that place for a short time, afterward entering Holbrook Normal School at Lebanon, Ind. After teaching various country schools he became principal of the high school at New London, and later of that at Kokomo. In 1872 he went to Indianapolis as secretary of the school board, and remained there until 1874, when he entered the University of Michigan at Ann Arbor, graduating in 1878. From 1878 to 1881 he was engaged on a survey of the Great Lakes, and from 1881 to 1883 he was assistant engineer of the Mississippi River Commission. After these six years in practical engineering he was appointed professor of civil engineering in Washington University, St. Louis. Here he remained for sixteen years and made many valuable contributions to technical literature. He resigned his position here to become dean of the College of Engineering at the University of Wisconsin. The two books of Professor Johnson on which his fame will most largely rest are his "Rule and Practice of Surveying" and "Modern Frame Structures." "Materials of Construction" and "Engineering Contracts and Specifications" have also had a wide circulation. "The Engineering Index" was started by Professor Johnson in 1883. Professor Johnson was a prominent member in many engineering societies, and the engineering profession owes no small debt to him.

LEGAL NOTES

AN INJUNCTION ASKED FOR—It is said that the H. Krantz Manufacturing Company, Brooklyn, N. Y., Crouse-Hinds Electric Company, Syracuse, N. Y., and Zimdars & Hunt, New York, have begun a joint suit for "trade libel" in the New York Supreme Court, on their own behalf and on behalf of other panel board manufacturers, against Charles L. Eidlitz and T. J. Murphy, as owners of the Murphy panel board patents. It is alleged that the defendants have issued printed notices which are claimed by the plaintiffs to be erroneous statements. An injunction is asked to stop the circulation of such publications.

ELECTRICAL SECURITIES

A more confident tone has characterized recent speculation. This is significant when the professional character of the dealings, the continued absence of the outside public, and the very small development of the expected semi-annual investment purchasing demand are taken into consideration. Then, again, the uncertain crop outlook, with the vicissitudes of the summer yet to be passed, and the continuation of the coal strike with its consequent loss of millions to employers and employed, as well as to general commerce, must also be taken into account. This season of the year can not be called propitious to a bull movement of any magnitude or duration, because of the difficulties of securing outside public support and cooperation. Yet the new average level is better than that recorded at the previous maximum, preliminary to the big panic of May of last year. The monetary situation is developing growing importance as a speculative factor, and this promises to become intensified rather than decreased. Rates for the past week have shown ease, although there has been an advance in time funds, owing to the general expectation that all rates would show an advancing tendency for the next few months, with a consequent increase in demand. So far as the coal strike is concerned, it has played an insignificant part in recent speculation. The strike is now well into its third month, and from surface indications there are not many signs of its termination, though the coming convention of the bituminous miners this week is expected to force a turning point in this condition.

ELECTRICAL SECURITIES FOR WEEK ENDING JULY 12.

New York:	Closing.
Brooklyn R. T.	67¾
Con. Gas	223½
Gen. Elec	313
Kings Co. Elec	199
Man. El	131½
Met. St. Ry	147½
N. Y. & N. J. Tel. Co	176
Westinghouse Mfg. Co	208

A mortgage dated July 1 has been filed in the office of the County Clerk of Kings County for $150,000,000. This was authorized by the stockholders of the Brooklyn Rapid Transit Company on March last, covering the property, stock, securities, etc., of the company. The Central Trust Company, of Manhattan, is the mortgagee, and the purpose of the mortgage is to allow the company to issue stock for this amount, the money raised to be used for the various improvements in the road, and for taking care of underlying mortgages as they become due.

Boston:	Closing.
Am. Telep. & Tel	165¾
Edison Elec	277
Mass. Elec. pf	98
New England Tel	141
Western Telephone & Telegraph	102½

The gross earnings for May of the Edison Electric Illuminating Company are $6,360, an increase of $521 over the same month in 1901. The net earnings are $1,856, an increase of $108. Net profit, without charges, is $1,127, an increase of $197.

The steady buying of American Telephone and Telegraph stock and rights has been the feature of the Boston market. This stock sold up to 167½. The instrument output statement for the month ending June 20 shows a net output of 54,912, against 62,079 for last year. The total outstanding is 2,088,854, against 2,228,107 at the same time in 1901.

Philadelphia:	Closing.
Elec. Co. of America	6¼
Elec. Stor. Bat. c	93
Elec. Stor. Bat. pf	93
Philadelphia Elec	5¼
Union Traction	45
United G. I. Co	107⅜

Electric Storage Battery developed considerable more strength during the latter part of the week, both the common and preferred gaining two points. The traction stocks were also in better demand and closed fractionally higher than last week.

The directors of the United Gas Improvement Company have declared a quarterly dividend of two per cent, payable July 15 to stockholders of record at the close of business June 30, 1902. The final steps have been taken which put the control of virtually all the street railways of Rhode Island, and a great part of the trolley lines of Connecticut, into the hands of the United Gas Improvement Company, of Philadelphia. There is an aggregate of 442 miles, of which 170 miles are operated by the Connecticut Railway and Lighting Company, and 272 miles are operated by the Providence Street Railway Company. This system is directly owned by the United Gas Improvement Company as a corporation. It is stated that influential officials of this company are now largely interested in the purchase of an equally large amount of mileage in trolley lines in and about Indianapolis.

Chicago:	Closing.
Chicago Edison Light	175
Chicago Telep	169
Metropolitan El. pf	89
National Carbon	27½
National Carbon pf	100
Union Traction	15½
Union Traction pf	50

ELECTRIC LIGHTING

SAN FRANCISCO, CAL.—The board of supervisors has adopted a resolution awarding the contract for lighting the public streets to the San Francisco Gas and Electric Company.

GLEN COVE, L. I.—The Franklin Electric Illuminating Company has voted to increase its capital stock from $35,000 to $60,000. The company's plant was recently doubled in size and capacity, but the growing business makes further outlay necessary. The company will furnish power for the Sea Cliff Street Railway.

NIAGARA FALLS, N. Y.—The town board of Niagara met at La Salle recently to consider the proposition of the Niagara Falls Gas and Electric Light Company. Mr. Dudley appeared for the company and offered to supply the town with gas and electric light from the Niagara Falls plant and the plant at La Salle.

CADILLAC, MICH.—L. J. Law, A. H. Webber, C. R. Smith and C. P. Litchfield have asked the city council for a franchise for heating, electric power, gas, refrigeration and ventilation plants in this city. The franchise will no doubt be granted at the next meeting of the council, and work on the building will begin within a few weeks.

FORT DODGE, IOWA—A deal has been consummated by which the controlling interest in the Fort Dodge Light and Power Company, including the Fort Dodge street railway, has been sold to a legal firm of this city. The transaction involves a transfer of $67,000 in stock in total issue of $125,000. It includes a gas and electric light plant and three miles of street railway. The new management announces that important improvements are contemplated.

ELECTRIC RAILWAYS

SHARON, PA.—Citizens of Orangeville, Gustavus and Kinsman are raising a fund to secure the extension of the Cleveland & Eastern Electric Railway to those places. The line will reach Sharon. If this line is built it will complete a trolley system between Cleveland and Pittsburg, and will make one of the longest lines in the country.

MORGANTOWN, W. VA.—The organization of the Morgantown Electric Light and Traction Company has been effected by the election of the following officers: President, I. C. White, of the University of West Virginia; vice-president, J. H. McDermott; secretary, Frank Cox; treasurer, E. M. Grant. The company was chartered some months ago, and it is now stated that its object is to connect the principal towns and five counties in northeastern West Virginia with Pittsburg by trolley. The company, it is said, will not build a trolley line alone, but will also eventually absorb all the electric lighting interests in that section of West Virginia, including those at Fairmont, Grafton and Clarksburg, all of which points and intermediate towns will be connected by trolley. The road will be, with all connections, about 215 miles long.

MINEOLA, L. I.—The Mineola, Hempstead & Freeport Traction Company has applied to the New York State Railroad Commissioners for permission to increase the capital stock of the company from $125,000 to $1,000,000, and to make a first mortgage loan of $1,000,000 to the Cleveland Trust Company as security for a bond issue, the proceeds of which are to be used in the construction of forty-six miles of railroad, providing three main lines between Mineola, Hempstead and Freeport and the city of New York, one on the south side, another on the north side and another through the centre of Nassau County, in addition to the line already constructed, tying together the three above-named villages. The entire enterprise has thus far been financed by Cleveland capital, and the bulk of the capital for future construction will come from that city.

INDUSTRIAL ITEMS

MR. A. M. BARRON, consulting engineer, South Bend, Ind., is distributing a business circular which presents the advantage of having a competent consultant engaged in looking into the operating and economic conditions of plants of all sizes.

THE WESTON ELECTRICAL INSTRUMENT COMPANY, Waverly Park, Newark, N. J., has issued two interesting bulletins, Nos. 2 and 4, descriptive of small isolated plant instruments and the round pattern direct-current voltmeters.

THE CENTURY TELEPHONE CONSTRUCTION COMPANY, manufacturer of telephones, switchboards and accessories, has moved its offices and factory to No. 336 Ellicott Square, Buffalo, N. Y. The company has adequate facilities for properly recognizing any order demanding the most severe requirements.

THE ELECTRIC APPLIANCE COMPANY, Chicago, Ill., is taking particular pride just now in its multiple burning sign lamp. This is very effective for advertising and decorative purposes, and is advantageous in window displays. This lamp is being sold quite extensively at present for sign work in connection with street fairs and expositions.

"FOUR-TRACK NEWS" for July, among many other interesting articles, contains one by Frank H. Fayant on "The Wonders of Electricity." This describes and illustrates some of the greatest electrical shops in the world and what they are achieving. Numerous other short sketches of interest and instruction complete this popular publication.

THE FOUNTAIN MANUFACTURING COMPANY, New York, advises that it has removed its general offices and salesroom to 15 Cortlandt street, where all communications should be addressed to the company. The company will retain as its New York stockroom its present quarters at 97 Bank street, where it carries a complete stock of junction, outlet and panel-board boxes, for the advantage of the local trade.

THE WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY is equipping the Illinois Glass Company with an extensive electrical equipment. The apparatus will be used for the operation of the machine, blacksmith and mould shops, and includes a 250-kilowatt, two-phase, 440-volt, sixty-cycle belted generator; twenty type "C" induction motors; thirty-eight type "O. D." transformers, and arc and incandescent lamps.

THE PITTSBURG TRANSFORMER COMPANY, Pittsburg, Pa., advises us that it carries in its New York office a complete stock of its type "K" transformers, and that correspondence addressed to the New York office will receive prompt attention. The New York office is under the management of Mr. A. A. Mustard. The company wishes it known that no advance is quoted over the regular prices for New York shipments.

SMITH & HEMENWAY COMPANY, New York city, has succeeded to the business of Thompson Brothers & Company, manufacturers of the improved Seavey mitre box. This succession includes the contracts, patents, good will, machinery, tools and plants. All of the business heretofore conducted by Thompson Brothers & Company will be promptly and satisfactorily taken care of by Smith & Hemenway Company.

MESSRS. R. H. MACY & COMPANY have awarded the Jandus Electric Company, Cleveland, Ohio, probably one of the largest contracts ever given for arc lamps outside of a central station. The contract is for 1,300 standard Jandus lamps, and will probably be extended to 1,500 before its completion. The lamps are to be used in the enormous new store of Macy's on Broadway, at Herald Square, and are for the complete illumination of the building.

THE STANDARD ELECTRIC COMPANY, Erie, Pa., makes the following announcement: "On July 17, 1902, this company will be incorporated under the laws of Pennsylvania, and to do this it will be necessary to adopt another name. After the above date our corporate name will be Federal Electric Company. There will be no change in the management. All contracts and obligations of the Standard Electric Company will be executed by the Federal Electric Company."

THE KELLOGG SWITCHBOARD AND SUPPLY COMPANY, Chicago, Ill., has secured a contract for 6,000 telephone sets. This order was placed as the result of a competitive telephone test at Scranton, Pa., of 400 miles over a long-distance line, conducted by Wilbur H. Johnston, chief engineer of the Frontier Telephone Company, Buffalo, N. Y. The company claims that the Kellogg transmitters have been tested on lines up to 1,500 miles and found to be perfectly satisfactory.

MR. W. R. BRIXEY, manufacturer of Kerite wires and cables, has had the satisfaction of successfully completing the very severe work of laying a deep-sea cable for the government off the coast of Alaska. There were several annoying delays and accidents, all of which have been overcome, and the government has promptly met its obligations by sending a check of six good figures to Mr. Brixey. This is the longest submarine cable ever made and laid by an American manufacturer.

THE WILLARD STORAGE BATTERY COMPANY, Cleveland, Ohio, has just issued a new catalogue descriptive of Willard storage batteries. It contains a description of the various types of the Willard batteries. The new company claims to have made many important improvements over the old type of battery as manufactured by its predecessor, Sipe & Sigler, and announces that it is now ready to accept orders for storage batteries, especially for street railway and lighting service.

THE ELECTRIC STORAGE BATTERY COMPANY, Philadelphia, Pa., presents to its patrons and all interested in the operation of storage batteries, a book of curves which graphically describes the operation of chloride accumulators in their typical applications to electric railways, central power stations, isolated lighting plants, etc. The company believes that it is submitting data which will be of assistance in the solution of problems concerning the economical production and distribution of electric power.

THE CONSUMERS' CARBON COMPANY, Lancaster, Ohio, has undergone a change in its officers. The present officers of the company are: C. S. Britton, of Cleveland, president; B. L. Britton, of Lancaster, Ohio, secretary and treasurer, and A. N. Britton, of Cleveland, vice-president. The company purposes to largely increase its factory facilities for the manufacture of a complete line of specialties in carbon, as well as for a larger production of electric light carbons which it has been making for the past two years.

THE STANDARD VITRIFIED CONDUIT COMPANY is a new corporation recently organized, with offices at 39 and 41 Cortlandt street, New York. The officers of the company are R. W. Lyle, president and manager, and B. S. Barnard, vice-president and secretary. The company advises us that it is preparing to manufacture in very large quantities vitrified salt glazed underground conduits, and insulators for third-rail equipment. Both the above-named gentlemen have had comprehensive experience in the manufacture of this product for electrical services, Mr. Lyle having been a long and careful student of clay work, and has perhaps produced a greater volume of clay materials than any other man in this country. Mr. Barnard has been sales manager for the American Vitrified Conduit Company and has a wide acquaintance and popularity in this field of engineering.

THE CROCKER-WHEELER COMPANY, Ampere, N. J., manufacturer of direct-current machinery, has included the following among recent orders: Standard Steel Works, Burnham, Pa., two, size 224, 200-kilowatt generators; James Cooper Manufacturing Company, Montreal, Canada, 55-kilowatt generator; Buda Foundry and Manufacturing Company, Harvey, Ill., size 280, 240-kilowatt generator; Whitehall Portland Cement Company, Cementon, Pa., 85-horse-power motor; Woodward & Lothrop, Washington, D. C., size 224, 200-kilowatt generator, two, size 168, 150-kilowatt generators, size 84, 75-kilowatt generator; Sparrell Print, Boston, Mass., 14 motors, 3 to 10 horse-power; Tidewater Steel Company, Chester, Pa., size 280, 250-kilowatt generator; Minot Light and Telephone Company, Minot, N. Dak., size 100-D, 90-kilowatt generator; Armor & Company, East St. Louis, Ill., four 50-horse-power motors, one 75-horse-power motor; Green Engine and Machine Company, Harrison, N. J., four 35-horse-power motors; Descubridora Mining and Smelting Company, Mexico, four 20-horse-power motors; Moline Malleable Iron Company, St. Charles, Ill., size 100-D, 90-kilowatt generator, 11 motors aggregating 125 horse-power; Pennsylvania Sugar Refinery, Philadelphia, Pa., 14 motors, 3 to 15 horse-power; Fretz Umbrella Works, Philadelphia, Pa., 80 motors in small sizes; Lake Shore & Michigan Southern Shops, Collinwood, Ohio, 11 motors, aggregating 200 horse-power, were shipped to apply on the installation in this plant. Speed control will be obtained by the Crocker-Wheeler system of multiple-voltage operation.